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M5.2.1

Models: E38 with M73/M73TU Engine
E38/E39 with M62 Engine

Production Date: E38 with M62 Engine 5/97 Through 98 MY
E39 with M62 Engine 9/97 Through 98 MY
E38 with M73 Engine 5/97 Through 98 MY
E38 with M73TU Engine 99 MY to Present

Manufacturer: Bosch

Pin Connector: 134 Pins - 5 Modular Connectors (2 ECMs on M73)

Objectives of the Module

After completing this module, you will be able to:

• Explain How the Power is Supplied to the Ignition Coils

• Describe the Air Shrouded Injector Control on the M73

• Understand Why the Idle Speed is Influenced by Battery Charge Logic

• Explain the Electrically Heated Thermostat Operation

• Understand the Elecrtic Catalytic Converter Function

• Describe What "ISN" Means

• Name the Location of Evaporative Components

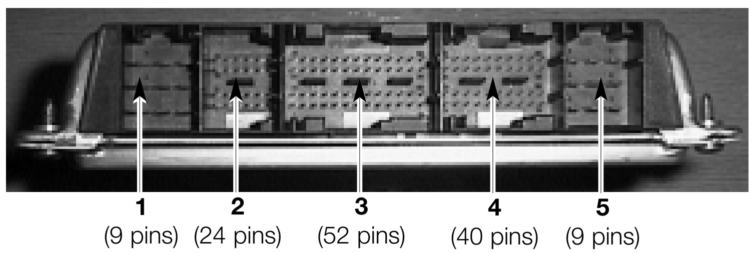
• List the Differences of the 99MY M73TU

M5.2.1 (1998 MY M73 & M62 equipped vehicles)

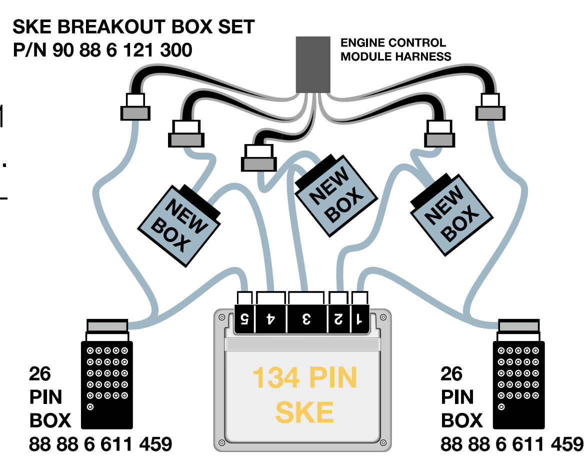
Purpose of the System

The M5.2.1 engine control system is manufactured by Bosch to BMW specifications. In addition to quality improvement modifications, emphasis was placed on enhancing functions for OBD II and Tier 1 compliance.

M5.2.1 control modules utilize the ***SKE*** (standard shell construction housing). The SKE utilizes a modular connector configuration. There are a total of 5 connectors providing a combined total of **134 pins.**



The modular harness connectors are color coded by cylinder bank on the M73. When removing control modules from the E-Box, note the color of the plugs and mark each module to prevent incorrect replacement. This step is important to prevent EWS III (3.3) ISN incompatibility.



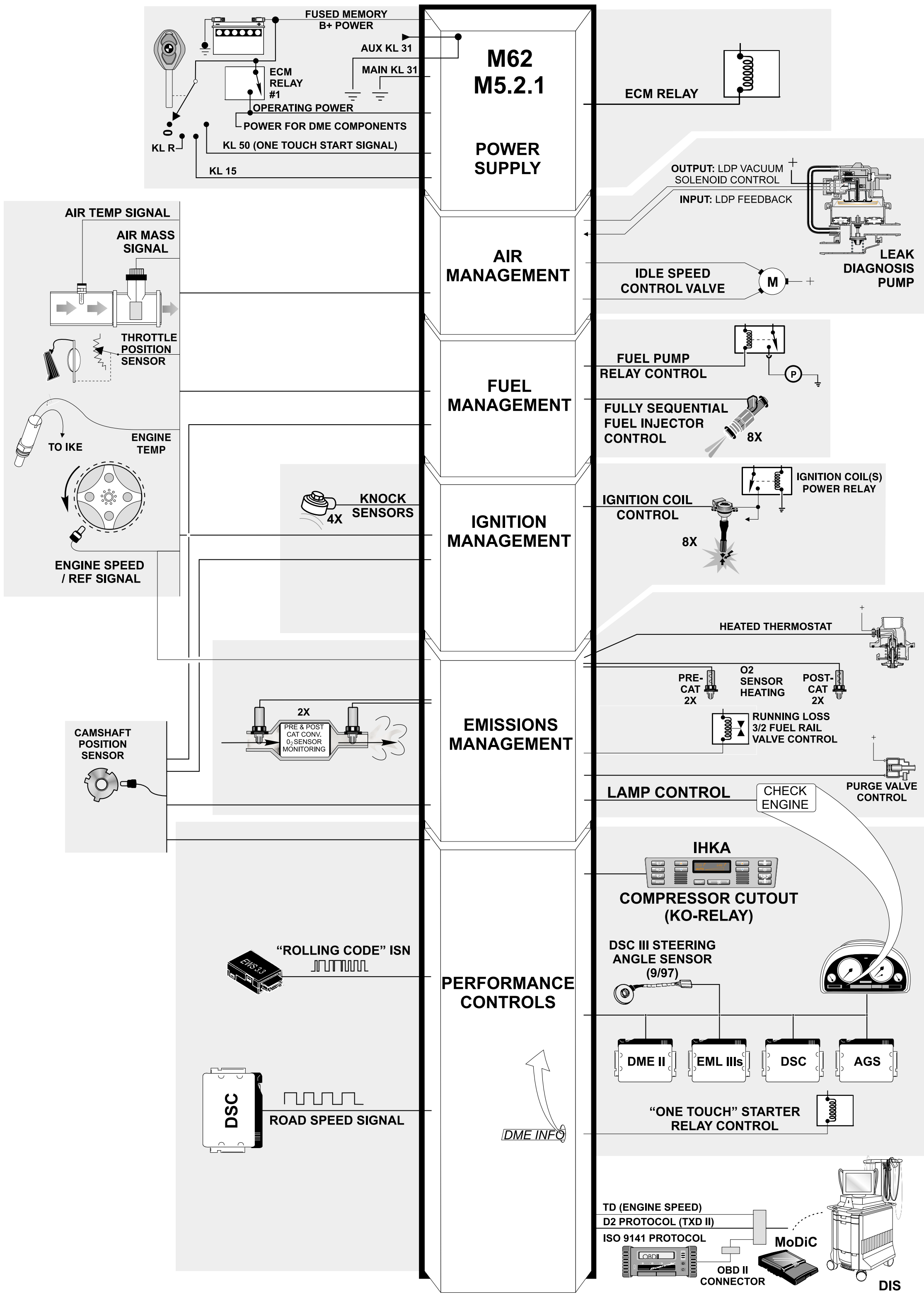
The correct Universal Adapter for the M5.2.1 application should be used (#90 88 6 121 300). This will ensure the pin connectors and the harness will not be damaged.

FEATURES OF M5.2.1

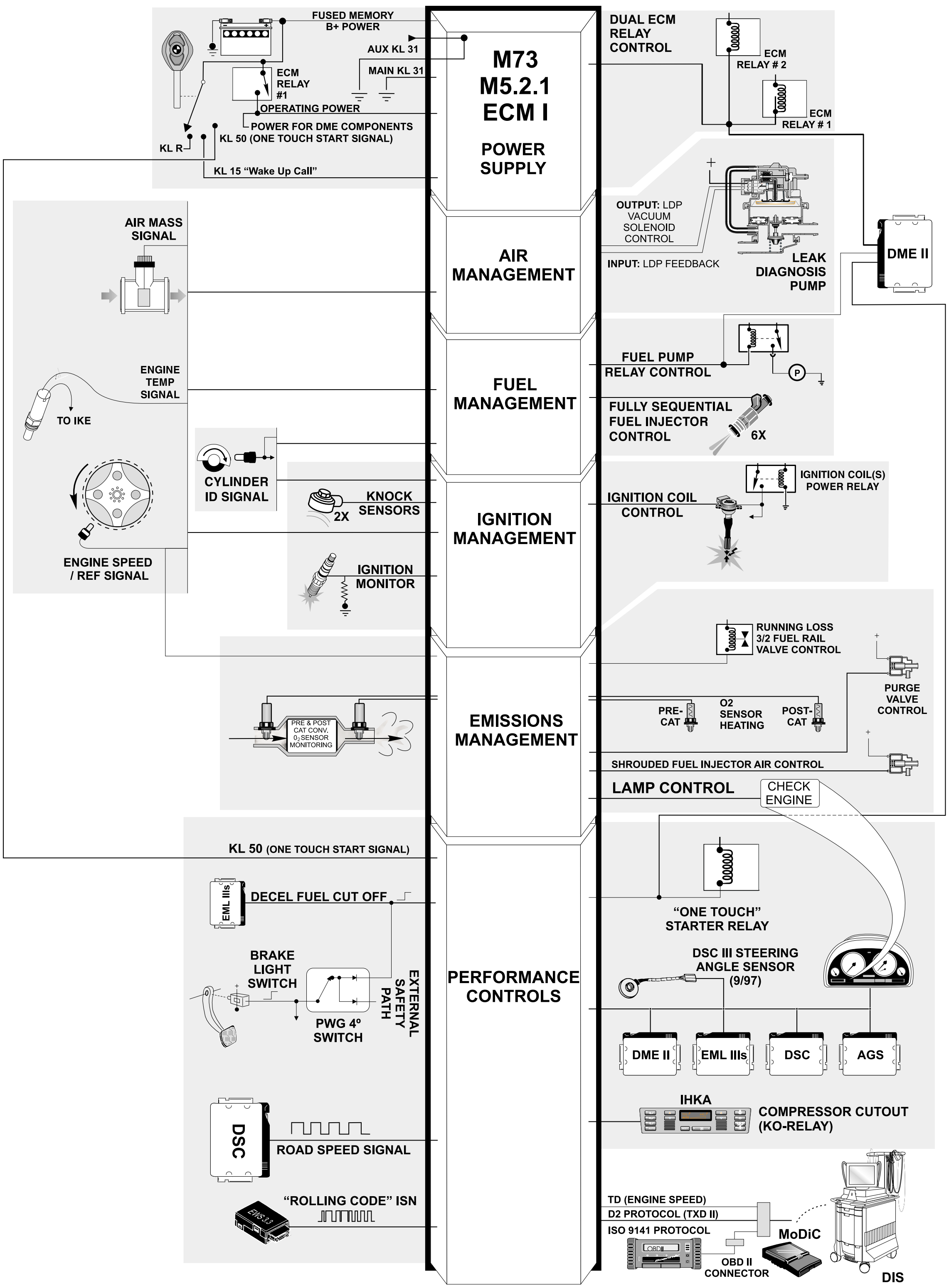
The M5.2.1 system has the following functions or capabilities:

- Separate power supply relay for ignition coils.
- Leak Diagnosis Pump control and feedback monitoring for evaporative system leak testing. Integration of this system also brought forth modifications to the total fuel evaporative system providing ORVR (On-board Refueling Vapor Recovery) compliancy.
- Shrouded Fuel Injector Air control ***(M73 Engine Only).***
- Battery charge logic (idle speed varied with the battery state of charge).
- CAN communications with the instrument cluster.
- “Rolling Code” ISN interface with EWS III (3.3).
- Knock Sensors are more sensitive in determining ignition knock.
- Pulse width modulated IHKA Status Signal (S-KO).
- Running Loss 3/2 Fuel Rail Valve

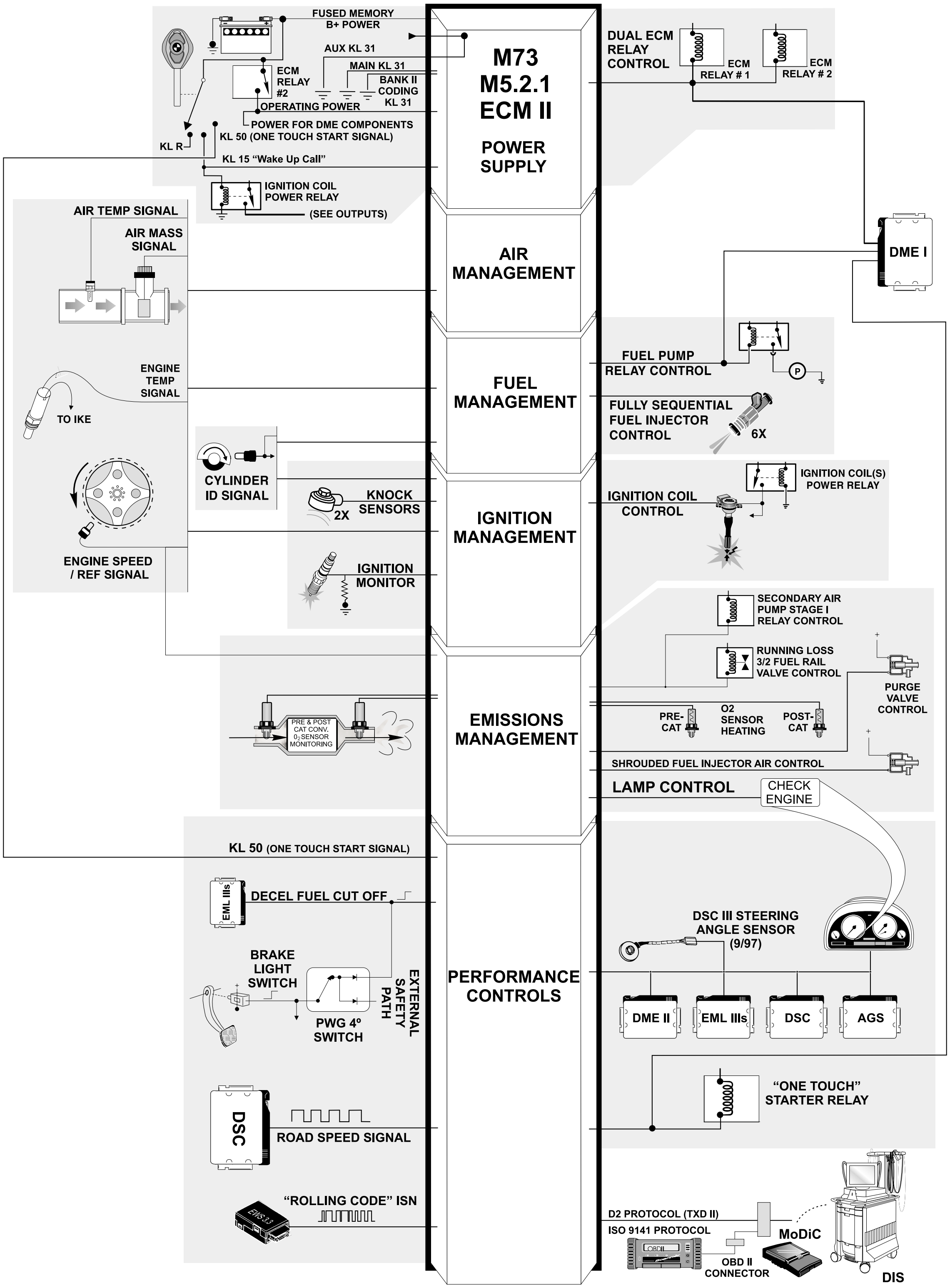
System Components: Inputs - Processing - Outputs



System Components: Inputs - Processing - Outputs



System Components: Inputs - Processing - Outputs

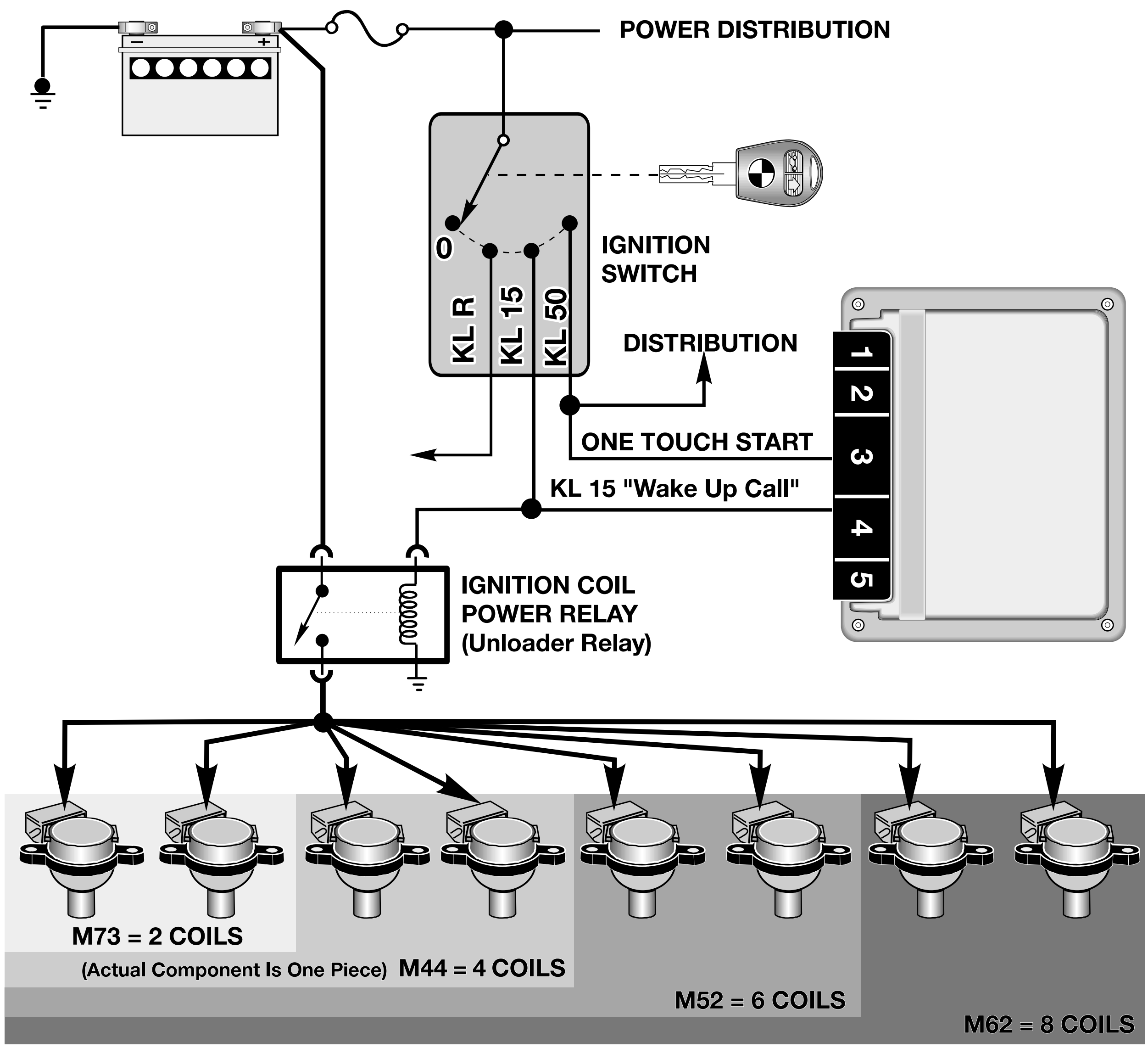


IGNITION COIL POWER SUPPLY (Unloader) RELAY

The power supply for the ignition coils is provided by a relay. This relay is identified as an ***"unloader relay"*** in the ETM and component listing displays.

The unloader relay was integrated into all vehicles starting with the 1997 model year. The purpose of this relay is to isolate the voltage supply as well as relieving the ignition switch of the additional current draw needed by the ignition coils.

When KL15 is switched on, the relay control circuit is provided power to close the relay providing operating voltage to ignition coils.



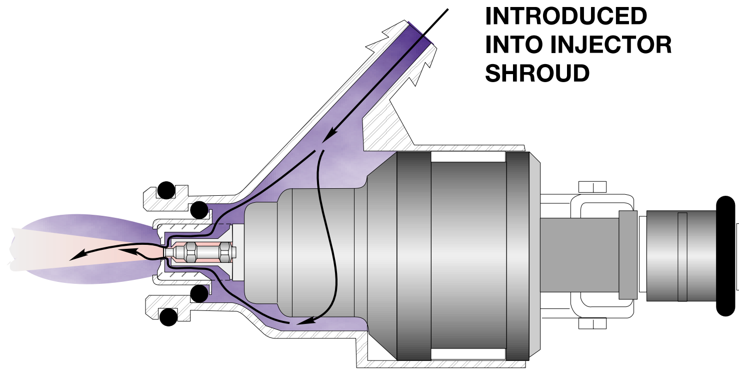
SHROUDED FUEL INJECTOR AIR CONTROL (M73 Equipped Vehicles only)

In compliance with emission regulations, air shrouded injectors are used on the M73 with M5.2.1. This system allows additional metered air to be drawn into the combustion chamber thus lowering CO/HC emissions.

With the air routing through the injector, it also creates additional turbulence to help atomize the fuel mixture.

The system is ECM controlled and uses the following components:

- 2 Air Containment solenoids for air inlet to the fuel injectors.
- Vacuum "balancing" bleeds to the intake manifolds.

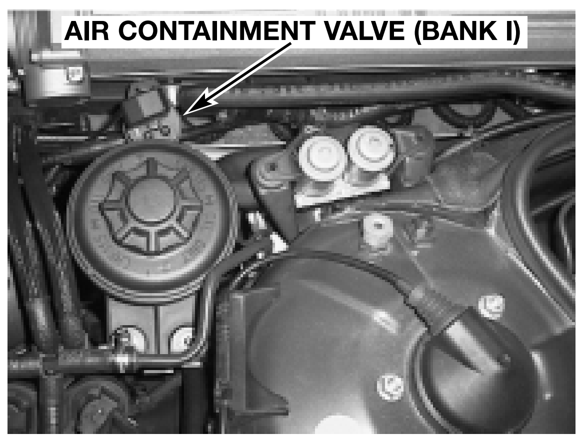


AIR MIXED WITH FUEL AT THE
PINTLE OPENING TO IMPROVE ATOMIZATION.

OPERATION

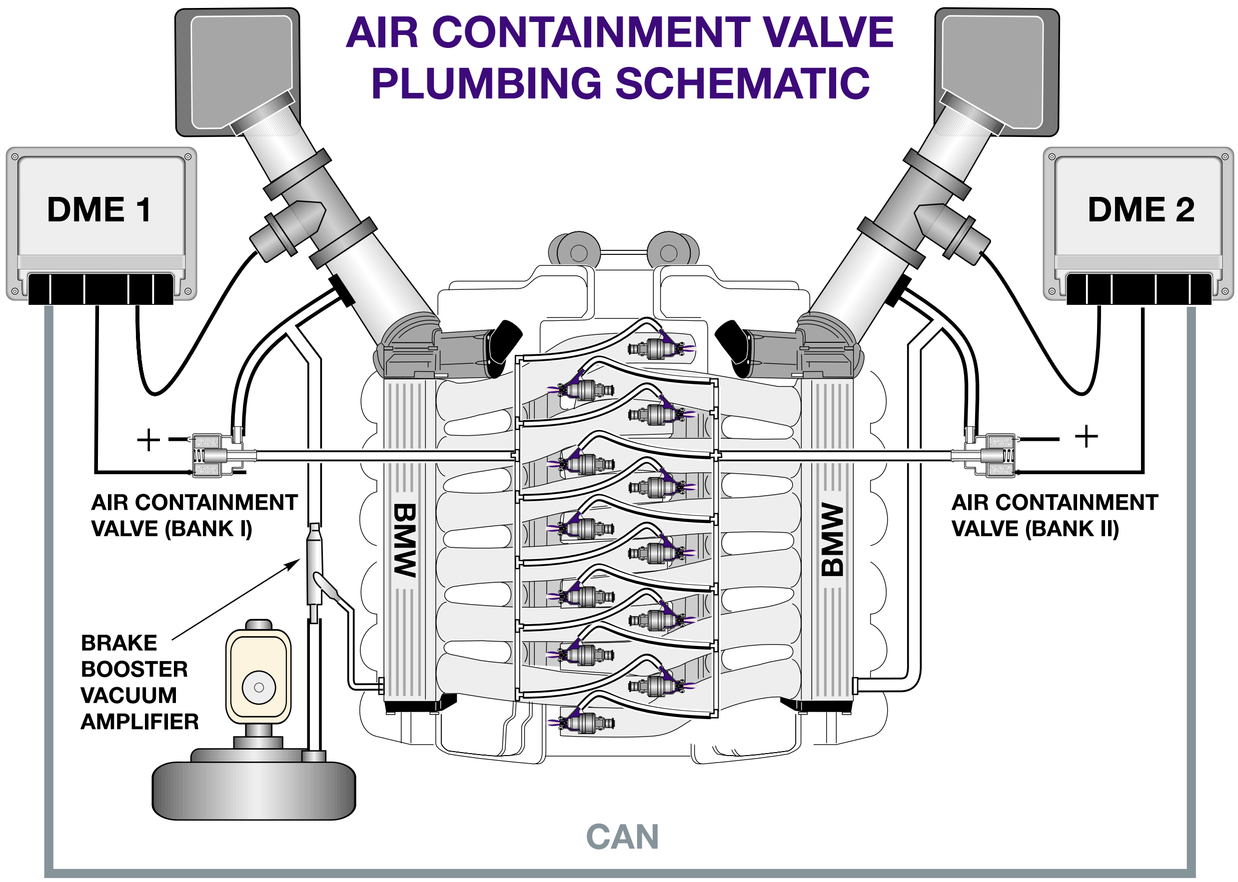
Operation of the system begins on cold engine start up. The ECMs provide a ground path to open the valves allowing additional metered air to be drawn into the fuel injectors to the manifold.

If the vehicle is stationary and idling, this process continues until the engine coolant temperature reaches 75°C. If the vehicle is started and driven, the additional air is injected through the warm up phase of the engine. The ECM then releases the ground path so the valves spring closed.



NOTE: Air injection will be interrupted during idle at engine operating temperature, if the idle speed becomes too high!

Similar to the M62, a brake booster is linked into the system by the vacuum amplifier. On the M73 this requires an equal "balance" of vacuum bleed on the opposite bank allowing equal DK motor synchronization. This system has fault recognition and is diagnosible using the DIS.


AIR CONTAINMENT VALVE
PLUMBING SCHEMATIC
DME 1
DME 2
AIR CONTAINMENT
VALVE (BANK I)
AIR CONTAINMENT
VALVE (BANK II)
BRAKE
BOOSTER
VACUUM
AMPLIFIER
BMW
BMW
CAN

BATTERY CHARGE LOGIC

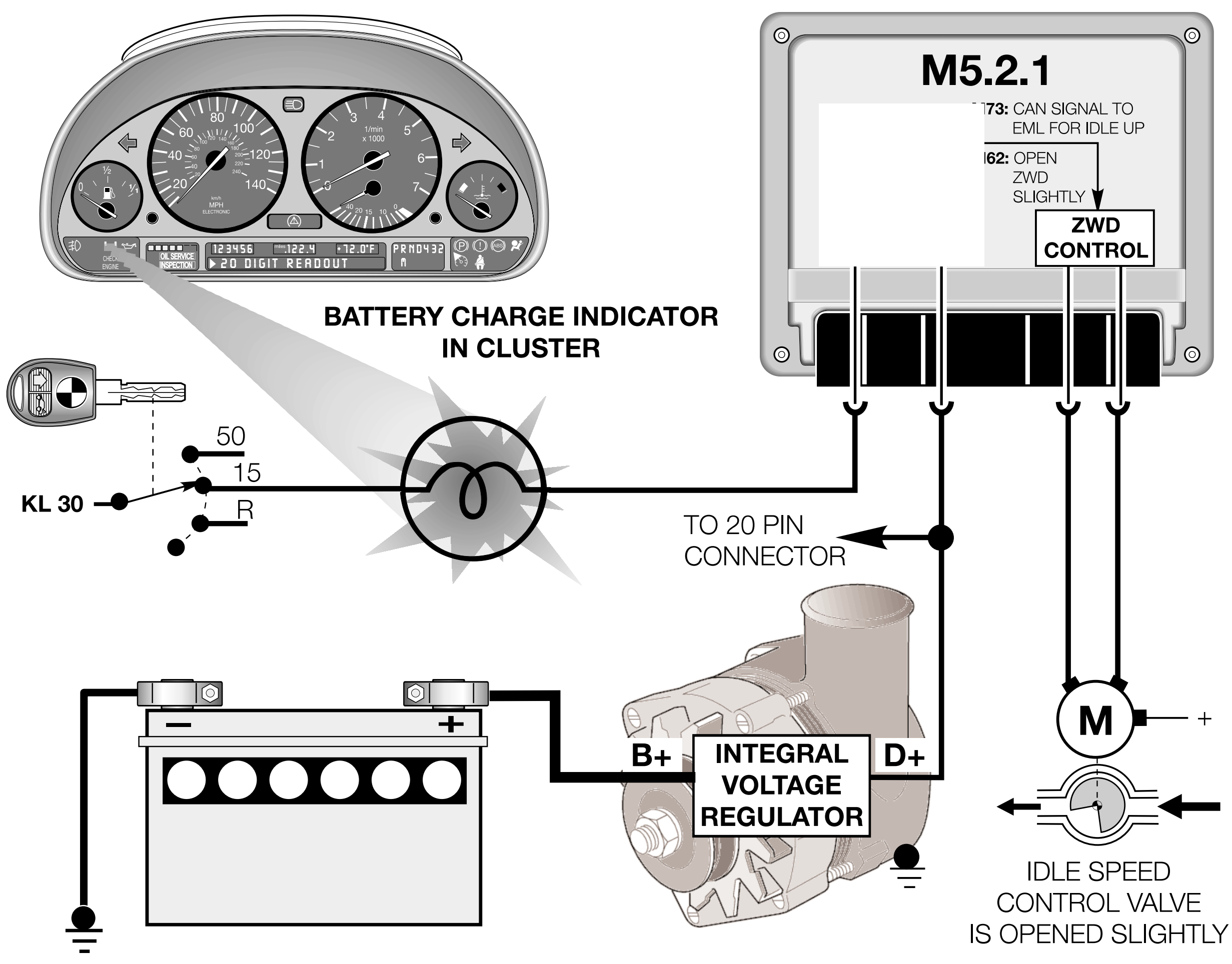
The 5.2.1 ECM (ECM 1 on the M73) monitors the “system voltage” from voltage supply inputs.

The following situations will occur upon engine start up:

- If the charging system output is sufficient, the engine rpm will be normal.
- If the charging system output is lower than normal, the engine idle will increase to provide a higher charge capability of the alternator.

  M62: The ECM opens the idle control valve slightly.
  M73: ECM I will request via “CAN bus” that the EML control module increase the engine rpm.

  Engine idle speed will be raised to 900 RPM until the generator output is sufficient.



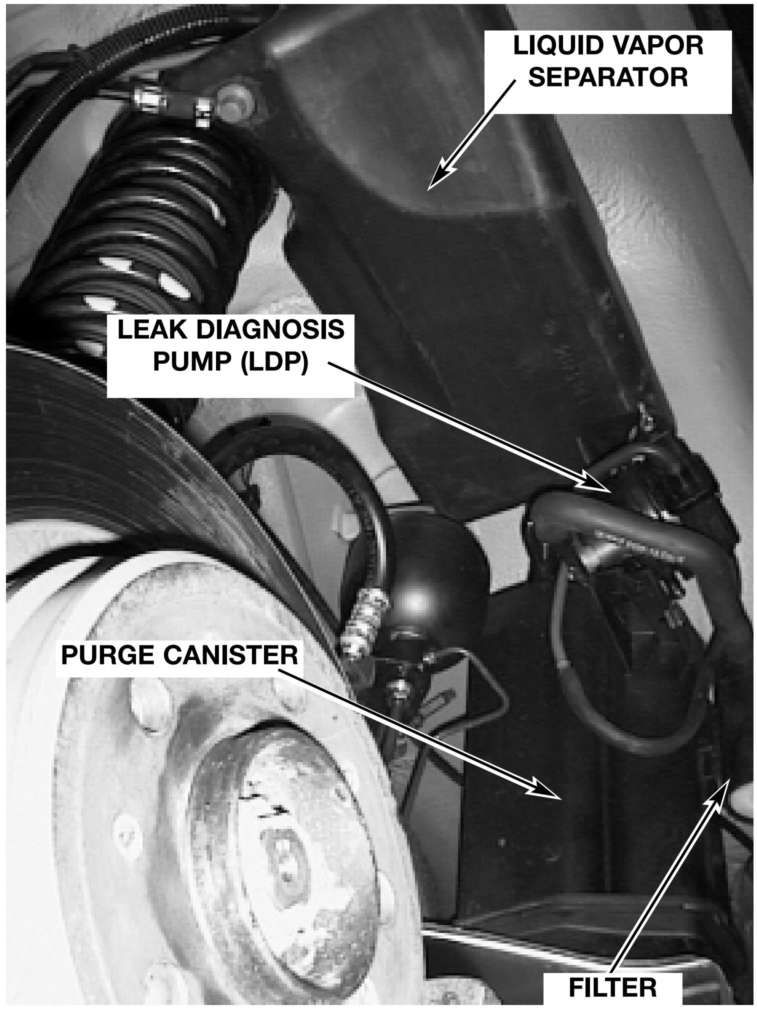
EVAPORATIVE FUEL SYSTEM PRESSURE LEAK DIAGNOSIS

To meet Tier 1 (emission stage) compliancy, a Leak Diagnosis Pump (LDP) is installed for fuel system evaporative leak testing.

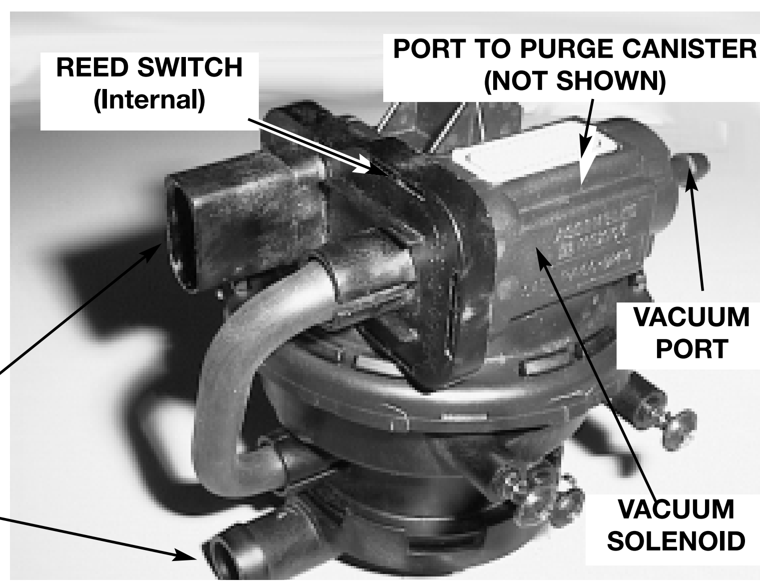
This system with the LDP is capable of detecting a leak ***as small as 0.5 mm.***

The LDP is located in the left rear (driver's side) fender well. The LDP is a unitized component that contains the following:

- Vacuum chamber
- Pneumatic pump chamber
- DME activated vacuum solenoid
- Reed switch providing a switched voltage feedback signal to the DME.



The vacuum supply line is in the wiring harness from the engine compartment and runs down the driver's side of the vehicle.



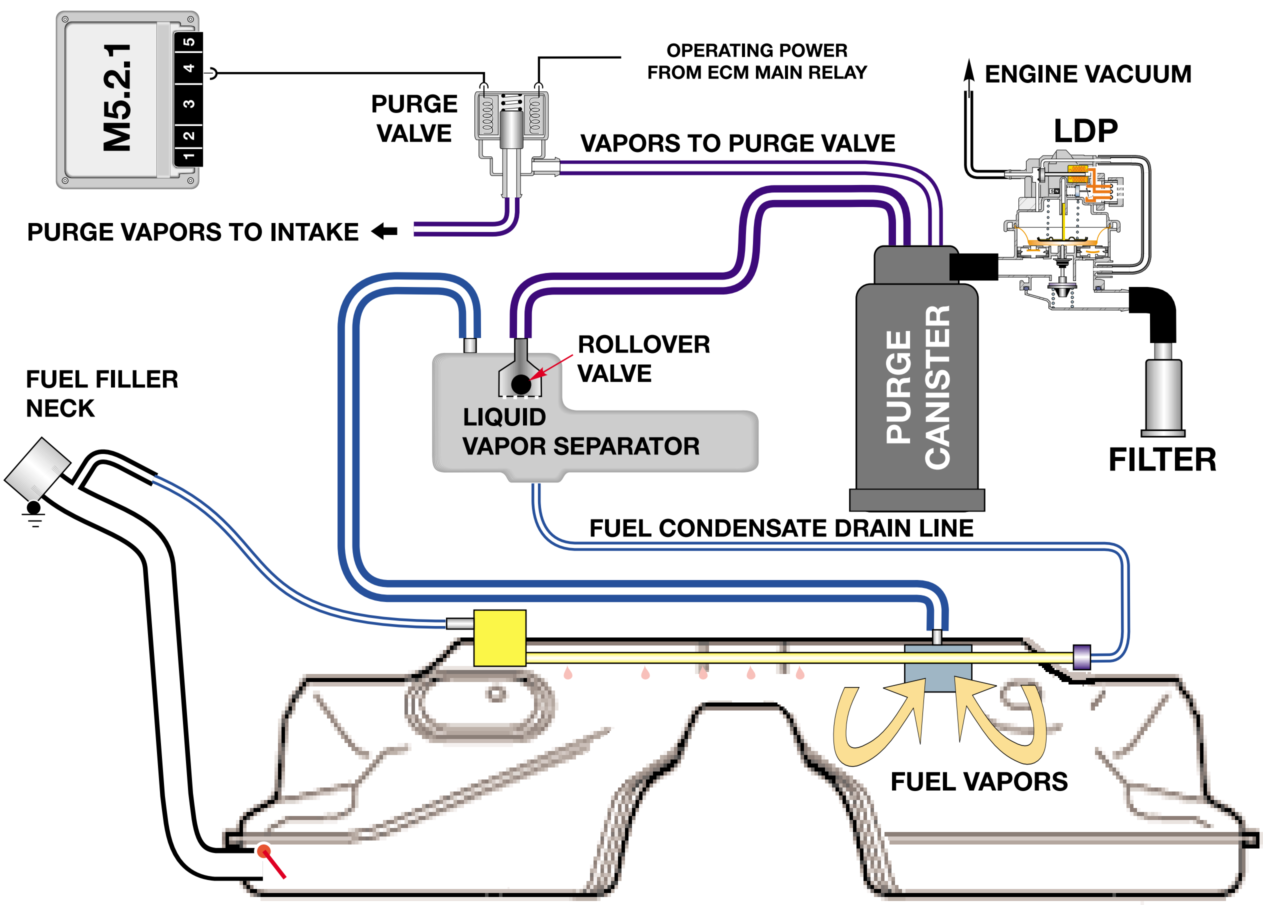
LDP-PURGE SYSTEM INTEGRATION

- The function of the LDP is to pressurize the fuel tank and the evaporative emission system (approx. 25mb.) for the purpose of detecting leaks.

- The canister vent valve is integrated into the LDP which is electrically controlled by the ECM. The canister vent valve is sprung open to provide fresh air entry into the fuel system during purge operation.

- Purge operation characteristics are:

  Off Idle through Full Throttle: Purge Valve(s) opened by pulse width modulated control of the ECM(s). Duty cycle varied by engine operating conditions.
  Warm Idle: Purge valve(s) open slightly
  Cold Idle/Decel: Engine temp < 67°C, Purge valve(s) closed.

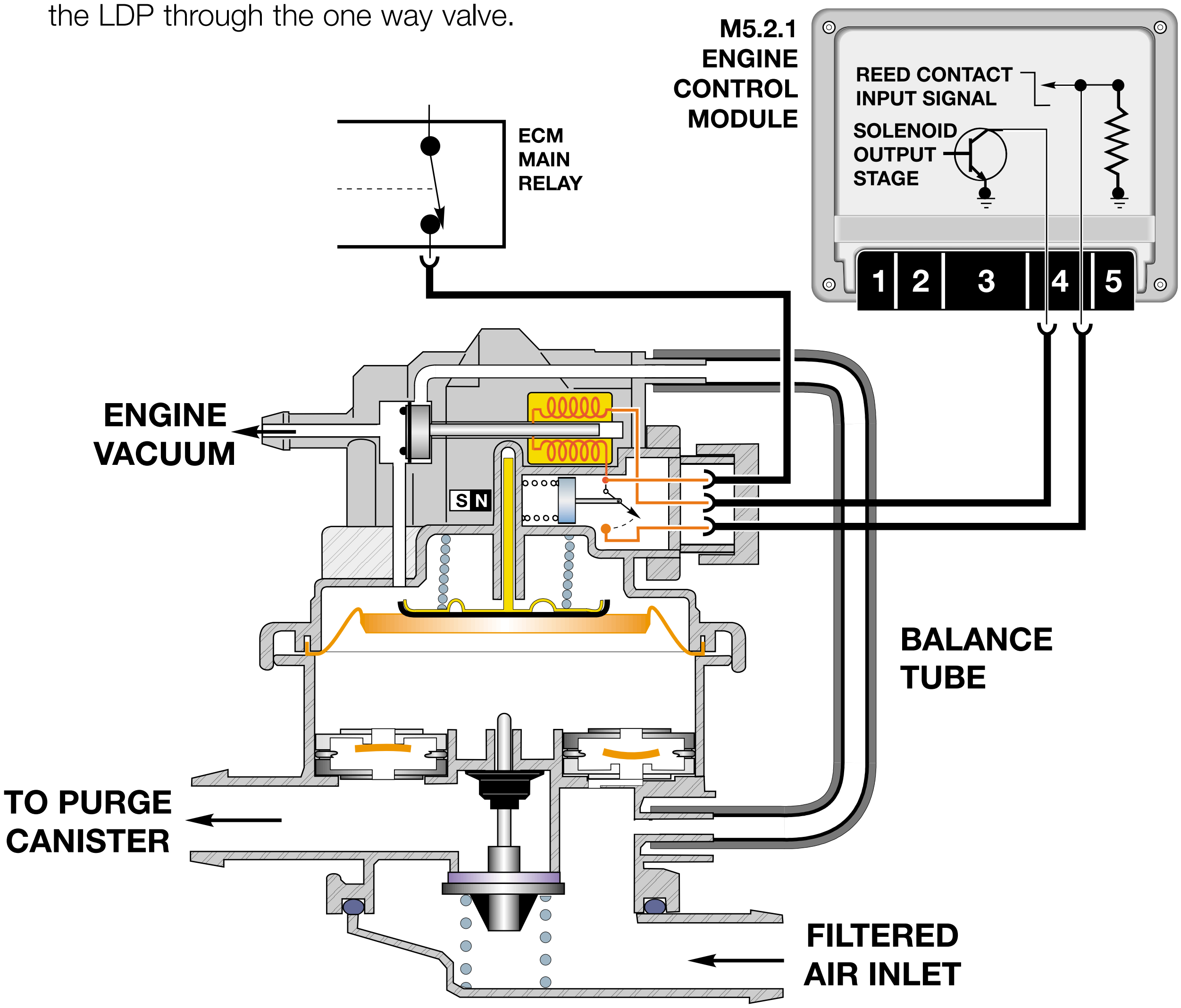


- During diagnostic testing of the evaporative emission system, the vent valve is closed and will block atmospheric venting. The purge valves are also sprung closed to seal the system.

LDP OPERATION

During every engine cold start, the following occurs:

- The LDP solenoid is energized by the ECM
- Engine manifold vacuum enters the upper chamber of the LDP to lift up the spring loaded diaphragm pulling ambient air through the filter and into the lower chamber of the LDP through the one way valve.

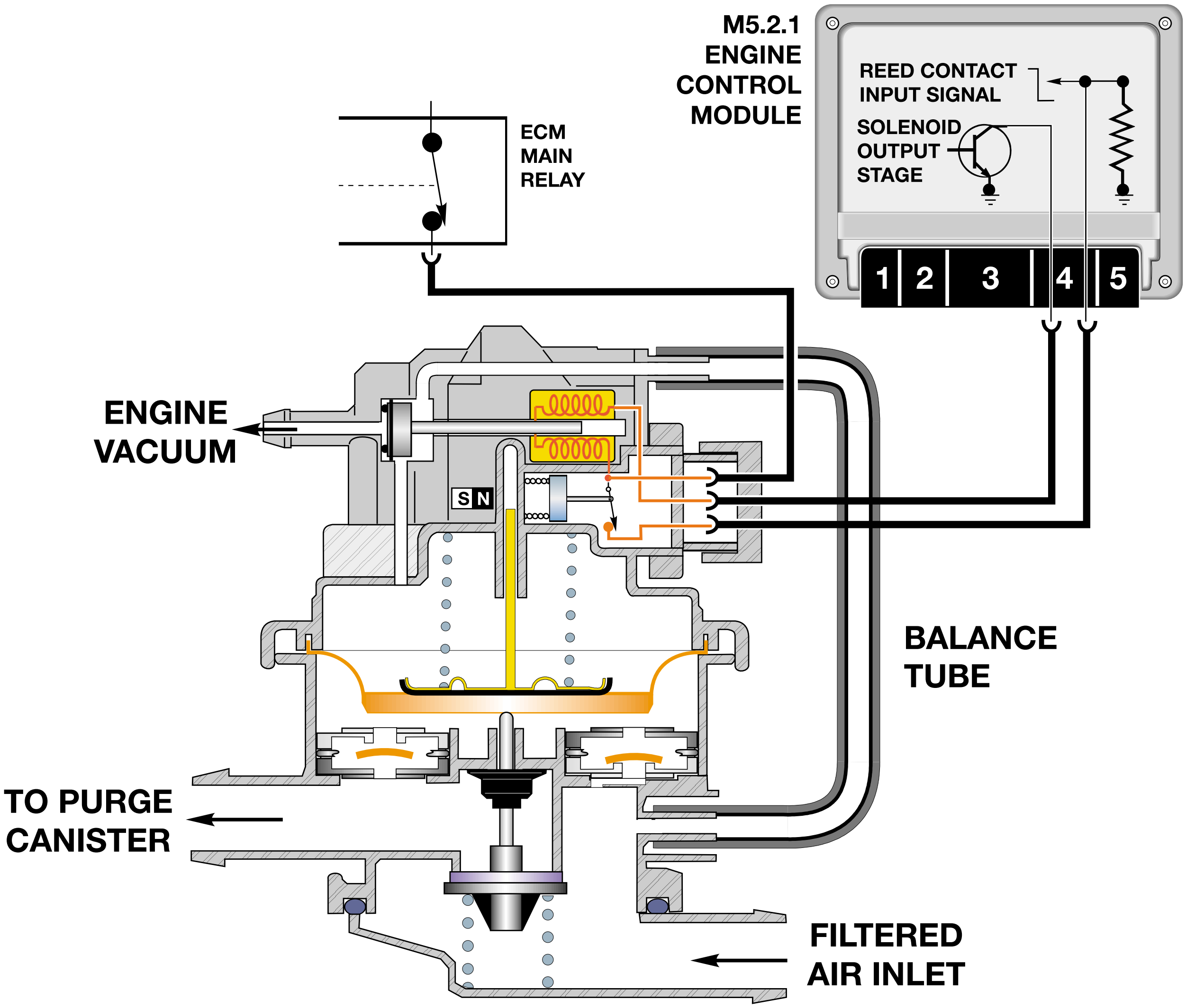


- The solenoid is then de-energized, spring pressure closes the vacuum port blocking the engine vacuum and simultaneously opens the vent port to the balance tube which releases the captive vacuum in the upper chamber.
- This allows the compressed spring to push the diaphragm down, starting the “limited down stroke”.

- The air that was drawn into the lower chamber of the LDP during the upstroke is forced out of the lower chamber and into the evaporative system.

- This electrically controlled repetitive up/down stroke is cycled repeatedly building up a total pressure of approximately +25mb in the evaporative system.

- After sufficient pressure has built up (LDP and its cycling is calibrated to the vehicle), the leak diagnosis begins and lasts about 100 seconds.



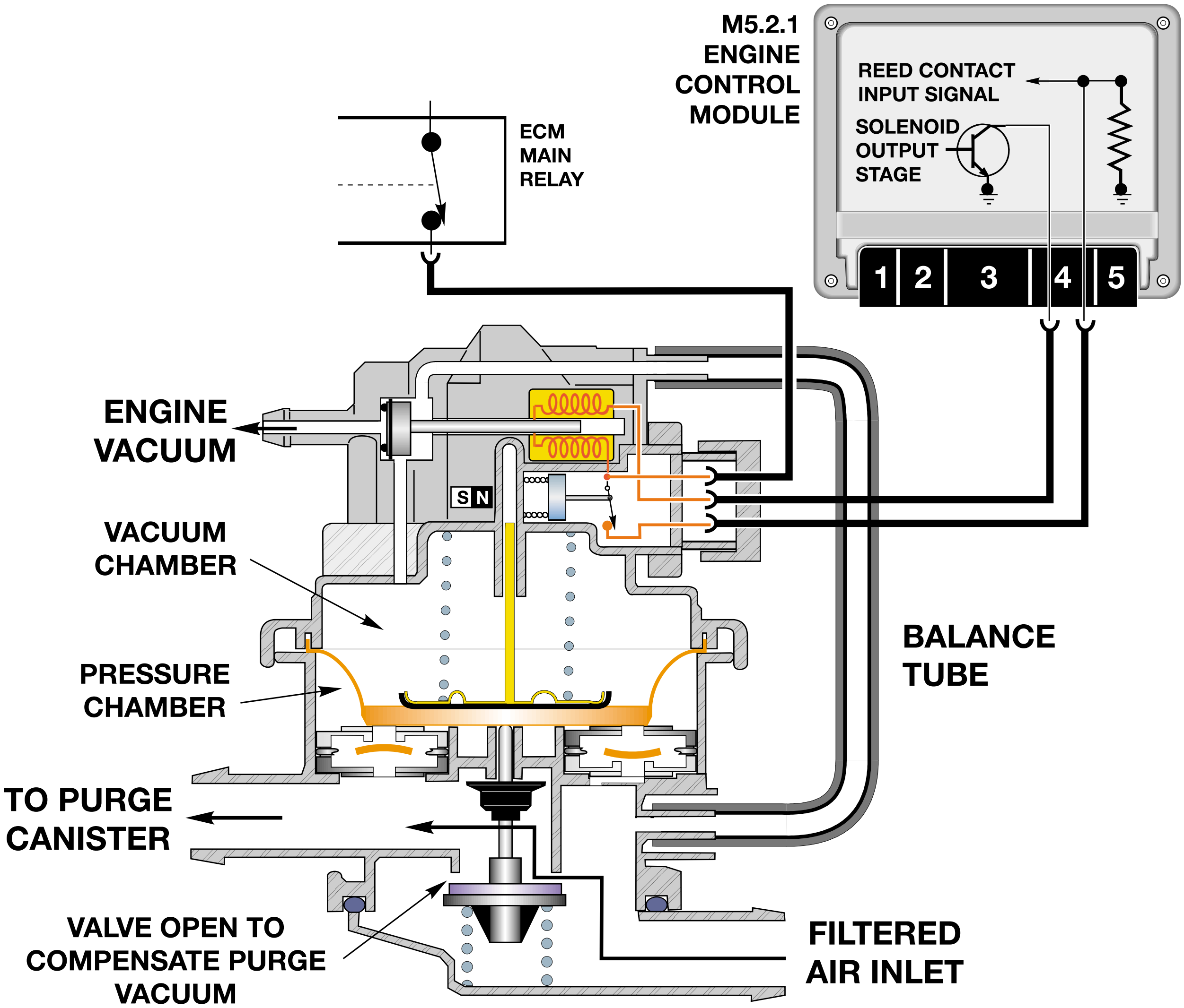
- The upper chamber contains an integrated reed switch that produces a switched high-low voltage signal that is monitored by the ECM. The switch is opened by the magnetic interruption of the metal rod connected to the diaphragm when in the diaphragm is in the top dead center position.

- The repetitive up/down stroke is confirmation to the ECM that the valve is functioning.

The ECM also monitors the length of time it takes for the reed switch to open, which is opposed by pressure under the diaphragm in the lower chamber. The LDP is still cycled, but at a frequency that depends upon the rate of pressure loss in the lower chamber.

- If the pumping frequency is below parameters, there is no leak present.

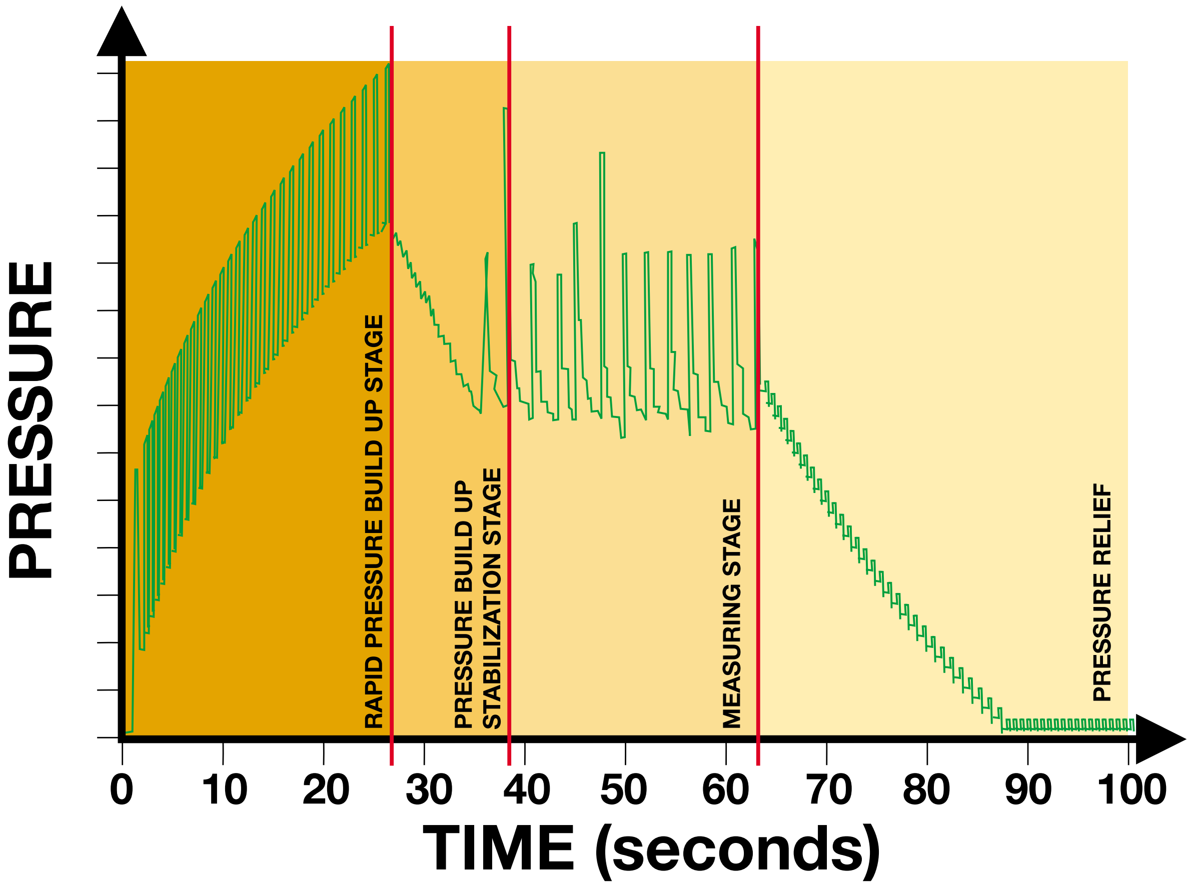
- If the pumping frequency is above parameters, this indicates sufficient pressure can not build up in the lower chamber and evaporative system, indicating a leak.



A fault code can be recorded by each ECM indicating an evaporative system leak. Upon test completion, the ECM releases the ground path to the LDP and the internal spring pushes the diaphragm for the “full down stroke”.

At bottom dead center, the diaphragm rod opens the canister vent valve. This allows for fresh air intake from the filter for normal purge system operation. The LDP is diagnosible with the DIS including a service function activation test.

The chart represents the diagnostic leak testing time frame in seconds. When the ignition is switched on, the ECM performs a “static check” of circuit integrity to the LDP pump including the reed switch.



- On cold engine start up, the pump is activated for the first 27 seconds at approximately 166-200 Hz. This rapid pumping phase is required to pressurize the evaporative components.
- Once pressurized, the build up phase then continues from 27-38 seconds. The ECM monitors the system through the reed switch to verify that pressure has stabilized.
- The measuring phase for leak diagnosis lasts from 38-63 seconds. The pump is activated but due to the pressure build up under the diaphragm, the pump moves slower. If the pump moves quickly, this indicates a lack of pressure or a leak. This registers as a fault in the ECM’s.
- From 63-100 seconds the pump is deactivated, allowing full down stroke of the diaphragm and rod. At the extreme bottom of rod travel, the canister vent valve is pushed open relieving pressure and allowing normal purge operation when needed.

ORVR FUNCTION (On-board Refueling Vapor Recovery)

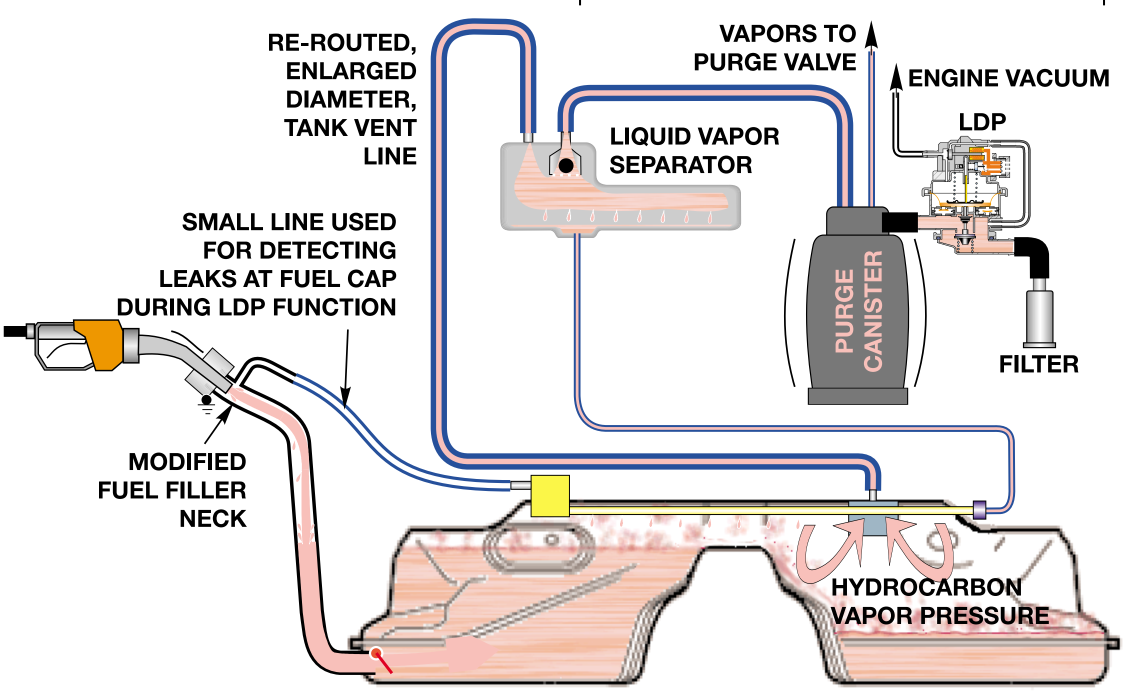
Any vehicle fitted with the LDP is also ORVR compliant. The ORVR system addresses recovering fuel vapor which is released during refueling. Previously, fuel vapors were vented from the tank venting line back to the filler neck and in many states reclaimed by a vacuum receiver on the filling station's fuel pump nozzle.

ORVR provides a means to "capture" these hydrocarbon vapors resulting from the rush of fuel into the tank during fuel filling. The following changes were installed to achieve this:

- Re-routing the previous tank vent hose from the filler neck to the liquid/vapor separator. This hose was also enlarged to accommodate the increased "vapor flow" being introduced into the liquid vapor separator.
- Enlarging the rollover valve and the hose from the liquid/vapor separator to the charcoal canister.
- Modified filler neck which allows a higher flow rate.
- Modifications to the fuel tank to form a liquid seal during refueling - forcing vapors to the liquid/vapor separator.

When refueling, the pressure of the fuel entering the tank will force the hydrocarbon vapors through the tank vent line to the liquid/vapor separator, through the rollover valve and into the charcoal canister. The hydrocarbons are stored in the charcoal canister, and the system can then "breathe" through the LDP pump and the air filter.

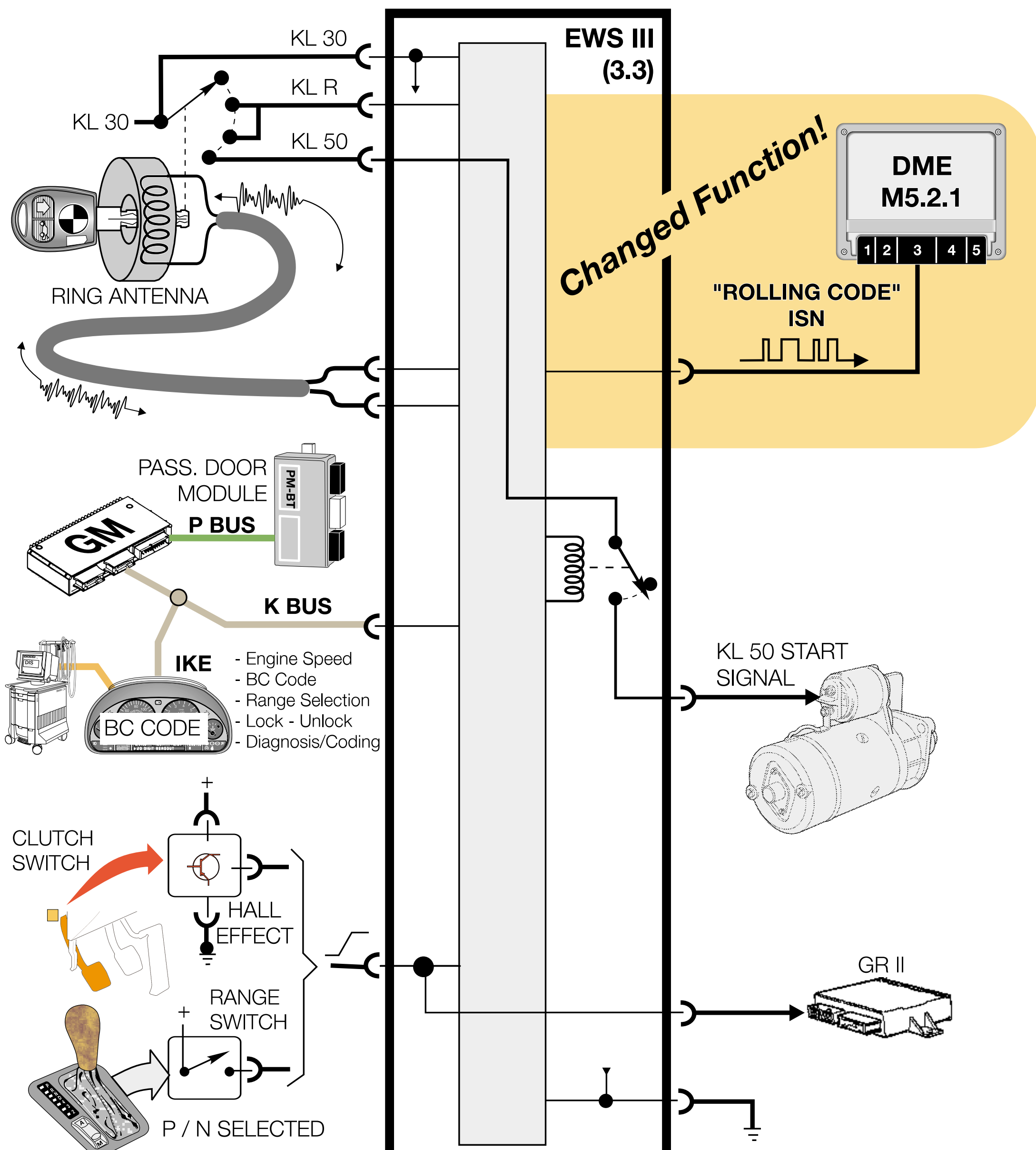
The small hose at the fuel filler neck is still required to check for leaks at the filler cap.



EWS III (3.3)

The EWS III is modified for compatibility with the M5.2.1 engine control system and is designated as **EWS 3.3.**

EWS 3.3 is installed in the 1998 MY E38 (from 5/97 production) and 1998 MY E39 (from 9/97 production). The system inputs remain unchanged compared with the 3.2 system, however, the ISN signal is now a **“Rolling Code ISN”.**



ROLLING CODE OPERATION

The “rolling code” is a one way signal from the EWS 3.3 to the ECM. The “Rolling Code” provides a higher level of sophistication than the ISN of previous EWS systems. Similar to the data exchange between the EWS control module and the transponder chip in each key, the “rolling code” is different every time the engine is started.

The rolling code system requires that each vehicle receive a unique “Rolling Code Table”. The rolling code table is assigned and installed by the factory into both the EWS 3.3 and M5.2.1 control modules. The code tables are “burned” into the control modules and can not be overwritten by ZCS encoding software, ECM programming software or the EWS/ECM Alignment Procedure of the Service Function section in the DIS for each system.

ENGINE STARTING PROCEDURE

- All EWS 3.3 input requirements are met:
  - System power and grounds provided
  - Positive data exchange between the key and EWS control module (key accepted).
  - BC code function is not active.
  - Range selector in P or N (E38s and 540iA), or Clutch pedal depressed (540i Sport).

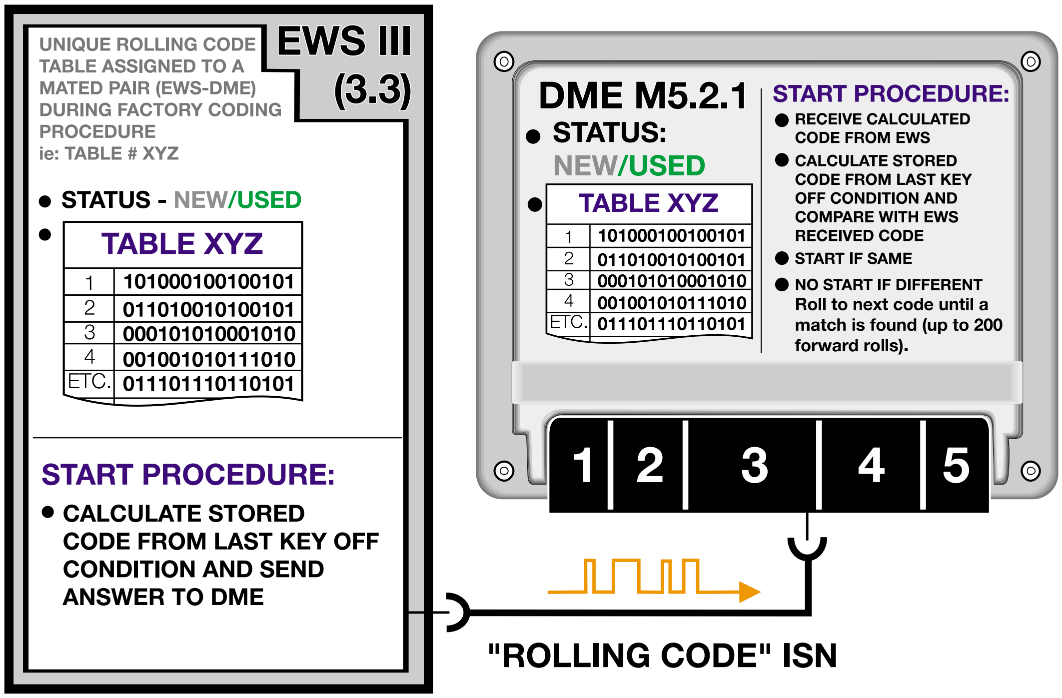
- EWS 3.3 control module closes the internal relay contacts providing the KL50 Start signal to the starter solenoid. Simultaneously, it calculates a stored code from the rolling code table and sends the calculated results to the ECM.

- On receipt of EWS’s calculated results, ECM calculates it’s own stored code and compares it’s results with the received results from EWS.

  - Results Identical: **Engine Starts!**
  - Results ***not*** identical: ECM “rolls forward” to the next code in the rolling code table and calculates it. It continues to “roll forward” until it finds a match. If no match is found: **Engine cranks but does not start!**

  The “forward roll” occurs up to a maximum of 200 times. This is necessary for the following reason. **Example scenario:** ECM is temporarily disconnected for service reasons. The ignition key is inadvertently switched on. When switched back off, the EWS is advanced one “rolling code” ahead of the ECM because the ECM was not connected. Once reconnected and the ignition key is turned to start, the ECM advances until a match is found. The rolling codes in each module are once again synchronized.

- When the ignition is switched off and no engine RPM signal is present in either the ECM and EWS, each module will automatically “roll forward” to the next pre-determined code (based on the code table.) This code is used for the next start sequence.



SERVICE INFORMATION

- Rolling code tables are rigidly assigned. For this reason, ECM control modules can not be swapped from another vehicle and re-aligned for troubleshooting purposes.

- Replacement EWS 3.3 control modules are ordered VIN specifically. They are received with the same rolling code table as the original module. Once ZCS encoded, the DIS software “resets” the current rolling code in the DME back to rolling code #1, providing synchronization in both modules.

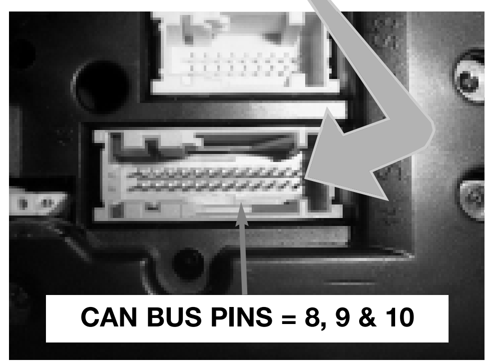
- Replacement ECM control modules are “off the shelf parts” and are “blank”. After ECM programming, the DIS software informs the EWS control module that a new ECM has been installed. With this information the EWS will send the entire rolling code table to the ECM on the next key on condition. It also resets itself to rolling code #1. The DIS software then informs the ECM that the first code it receives from the EWS is actually the rolling code table. When it’s received ECM automatically “burns” it into it’s memory.

- The alignment procedure is still available in the **SERVICE FUNCTIONS** menus of EWS or ECM. This procedure only “resets” the rolling codes back to #1 in each module. **It does not change the coding tables.** The ignition key must be switched off for 10 seconds after the adjustment is completed.

- **Final note:** ***Once a DME control module is programmed it can not be used in any other vehicle!!***

IKE MODIFICATION - CAN BUS ADDITIONS

The external IKE control module was been incorporated into the Instrument Cluster for the 1998 model year. If IKE replacement is necessary, a complete “Cluster” must be ordered and ZCS encoded at time of replacement.



The CAN bus has also been linked to the Instrument Cluster in the 98 model year. The cluster is an important link in the system, and vital information is now updated faster to the control modules.

The CAN bus connection to the instrument cluster is found at pins 8, 9 and 10 of the blue 26 pin ELO connector on the back.

The signals transmitted from M5.2.1 ECM over the CAN bus to the instrument cluster include:

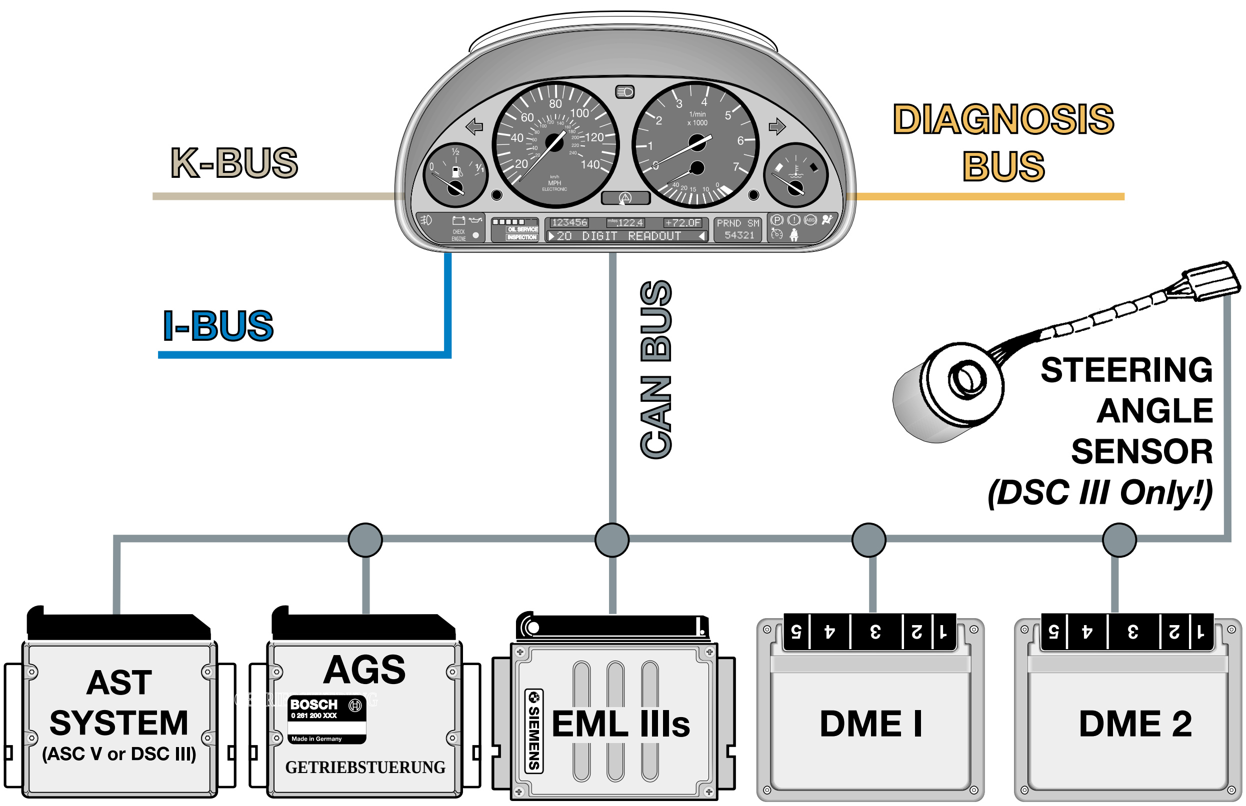
- Engine temperature
- Engine rpm
- Ti signal (MPG Gauge)
- “CHECK ENGINE” Light activation

A malfunction with the interface to the instrument cluster could cause the ASC and transmission fail-safe indicators to appear. In addition, the instruments affected by the signals listed above will be inoperative.

The CAN bus users as of the 98 E38 and E39 vehicles are:

- ECM (750iL: ECM 1&2)
- AGS
- ABS/ASC-DSC
- EML IIIs (750iL)
- Instrument Cluster
- Steering Angle Sensor (DSC III vehicles only, 9/97 production)

Note: The CAN Bus network of the 528i does not include the instrument cluster until 3/98 production.



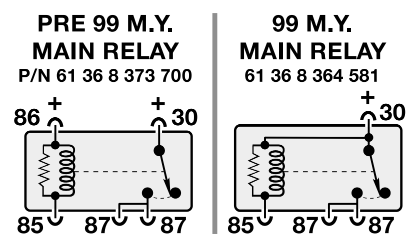
M5.2.1 FOR 1999 MY M73 TU

M5.2.1 continues to be used for the M73 TU 750iL. To meet LEV compliance there are additional functions included in the 1999 model year variant.

M5.2.1 Engine Management System Changes:

- Minimum idle speed reduction (530 rpm).
- Long-life spark plugs.
- Input signal from Radiator Outlet Temperature sensor.
- E-CAT control program function responsibility of ECM.
- CAN bus configuration = twisted pair wiring.
- Electrically heated coolant system map thermostat.
- Two speed Secondary Air Injection system control as with previous engine. Expanded pin assignments to improve comprehensive component monitoring.
- Variable IHKA auxiliary condenser fan speed control.
- ECM Relay Wiring Configuration.
- Air Shrouded Fuel Injectors with dual cone spray pattern.

M73 TU ECM Relays

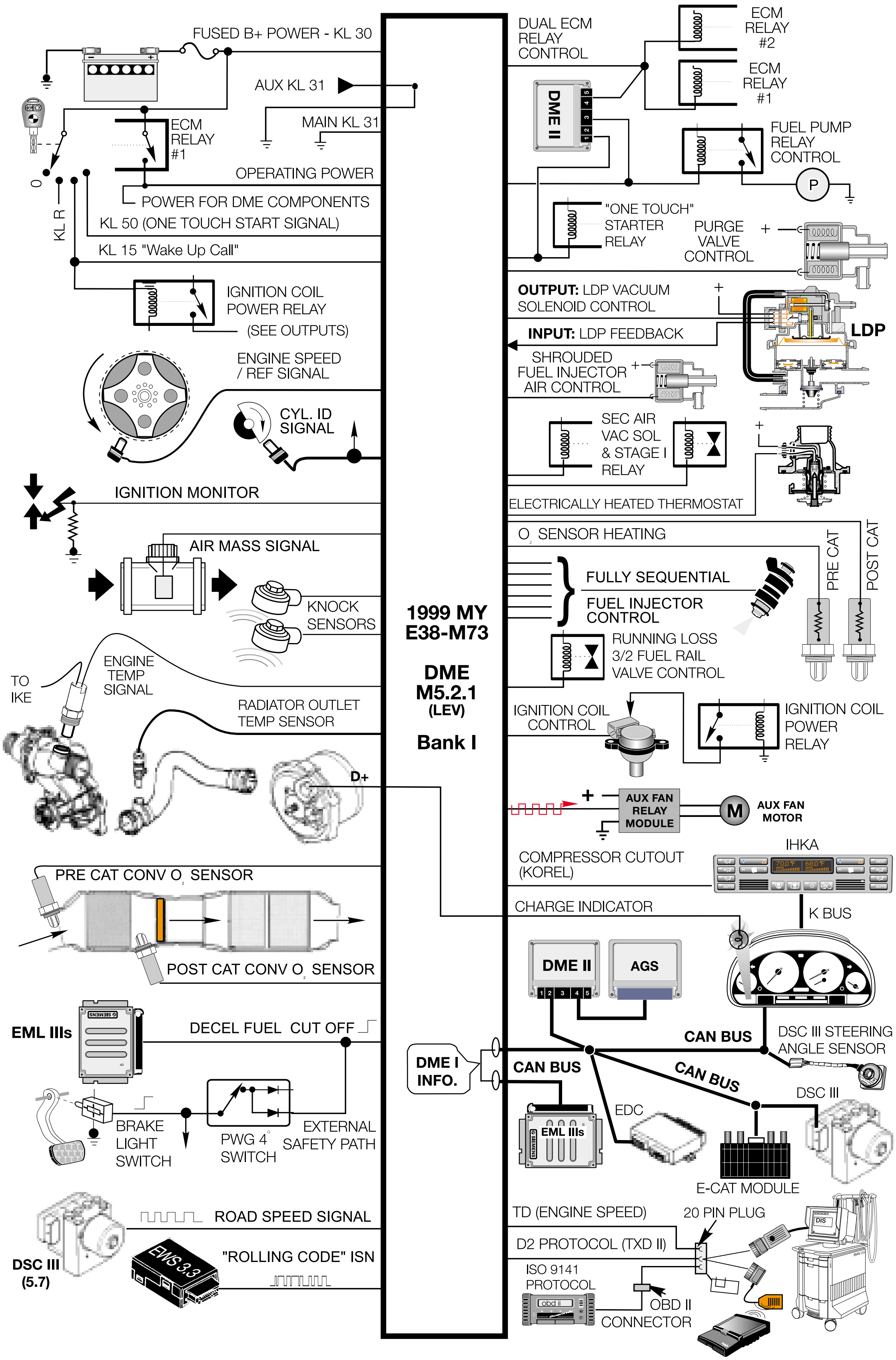


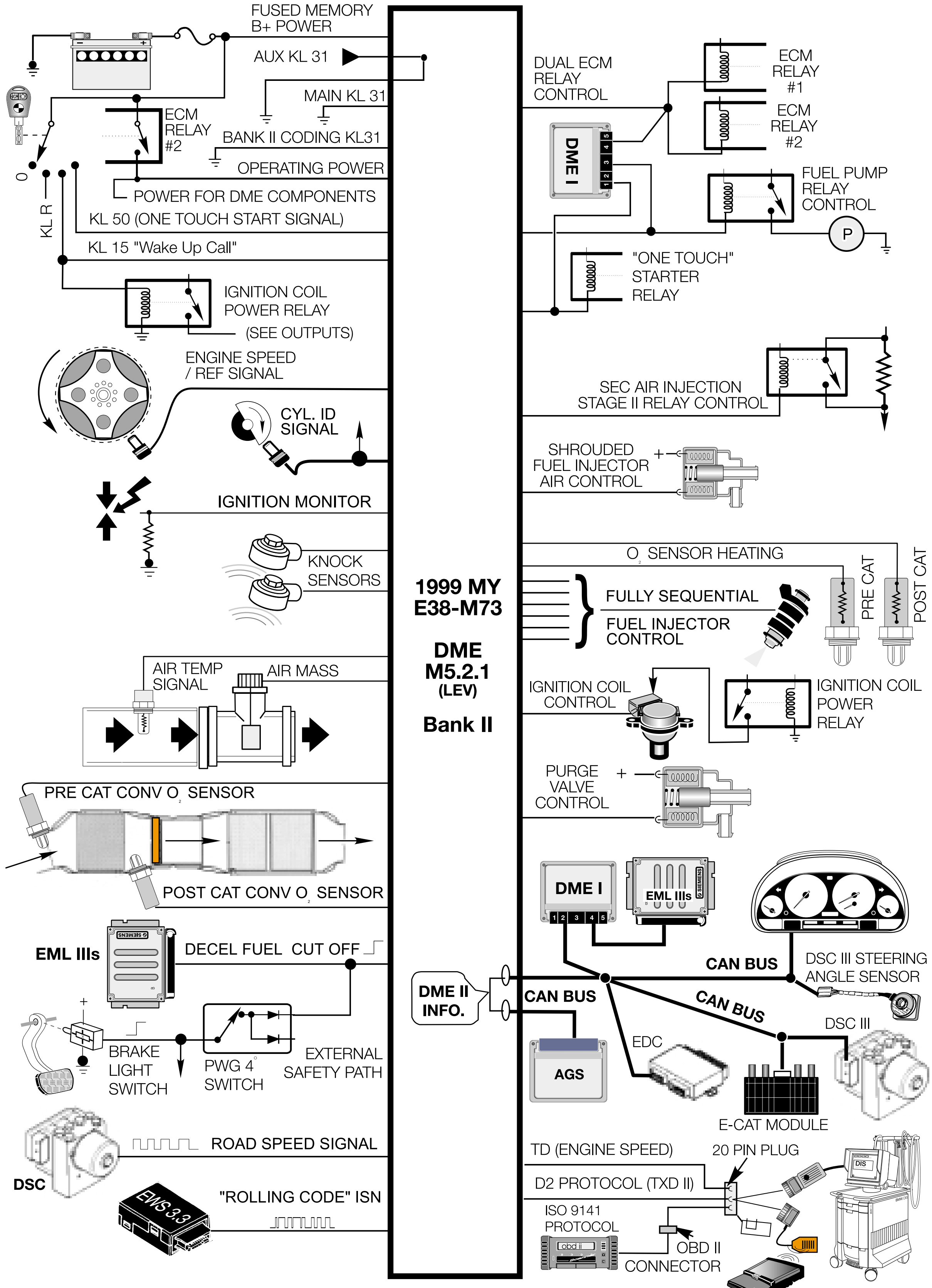
The ECM Relays are now manufactured with an internal control circuit power supply splice off of terminal 30. Terminal 86 has been omitted.

M73 TU Air Shrouded Fuel Injectors

The air shrouded fuel injectors of the M73 TU incorporate a new dual port injection spray plate in the injector tip that produces a dual cone spray pattern. The dual cone spray pattern improves atomization by separating the spray jets into two streams.

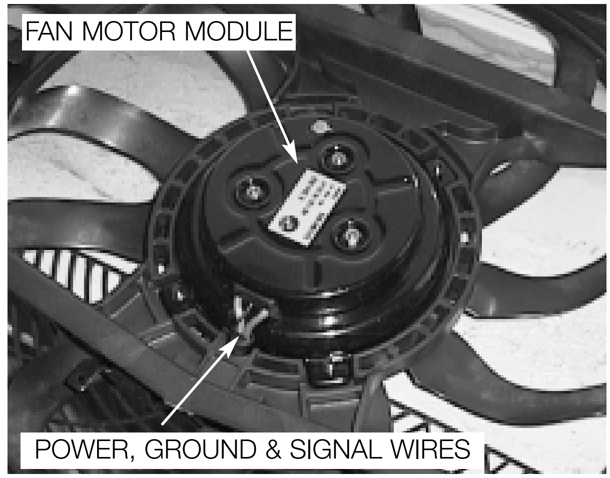
The injectors have an ohmic value of 15 ohms.


FUSED B+ POWER - KL 30
AUX KL 31
MAIN KL 31
ECM RELAY #1
OPERATING POWER
POWER FOR DME COMPONENTS
KL 50 (ONE TOUCH START SIGNAL)
KL 15 "Wake Up Call"
KL R
0
IGNITION COIL POWER RELAY
(SEE OUTPUTS)
ENGINE SPEED / REF SIGNAL
CYL. ID SIGNAL
IGNITION MONITOR
AIR MASS SIGNAL
KNOCK SENSORS
TO IKE
ENGINE TEMP SIGNAL
RADIATOR OUTLET TEMP SENSOR
D+
PRE CAT CONV O2 SENSOR
POST CAT CONV O2 SENSOR
EML IIIs
DECEL FUEL CUT OFF
BRAKE LIGHT SWITCH
PWG 4° SWITCH
EXTERNAL SAFETY PATH
ROAD SPEED SIGNAL
DSC III (5.7)
"ROLLING CODE" ISN
EWS 3.3
1999 MY E38-M73
DME M5.2.1 (LEV)
Bank I
DME I INFO.
DUAL ECM RELAY CONTROL
DME II
ECM RELAY #2
ECM RELAY #1
FUEL PUMP RELAY CONTROL
P
"ONE TOUCH" STARTER RELAY
PURGE VALVE CONTROL
OUTPUT: LDP VACUUM SOLENOID CONTROL
INPUT: LDP FEEDBACK
LDP
SHROUDED FUEL INJECTOR AIR CONTROL
SEC AIR VAC SOL & STAGE I RELAY
ELECTRICALLY HEATED THERMOSTAT
O2 SENSOR HEATING
PRE CAT
POST CAT
FULLY SEQUENTIAL FUEL INJECTOR CONTROL
RUNNING LOSS 3/2 FUEL RAIL VALVE CONTROL
IGNITION COIL CONTROL
IGNITION COIL POWER RELAY
AUX FAN RELAY MODULE
M
AUX FAN MOTOR
COMPRESSOR CUTOUT (KOREL)
IHKA
CHARGE INDICATOR
K BUS
DME II
AGS
CAN BUS
DSC III STEERING ANGLE SENSOR
CAN BUS
CAN BUS
DSC III
EDC
EML IIIs
E-CAT MODULE
TD (ENGINE SPEED)
20 PIN PLUG
D2 PROTOCOL (TXD II)
ISO 9141 PROTOCOL
OBD II CONNECTOR
DIS


FUSED MEMORY
B+ POWER
AUX KL 31
MAIN KL 31
ECM
RELAY
#2
BANK II CODING KL31
OPERATING POWER
POWER FOR DME COMPONENTS
KL 50 (ONE TOUCH START SIGNAL)
KL 15 "Wake Up Call"
0
KL R
IGNITION COIL
POWER RELAY
(SEE OUTPUTS)
ENGINE SPEED
/ REF SIGNAL
CYL. ID
SIGNAL
IGNITION MONITOR
KNOCK
SENSORS
AIR TEMP
SIGNAL
AIR MASS
PRE CAT CONV O2 SENSOR
POST CAT CONV O2 SENSOR
EML IIIs
DECEL FUEL CUT OFF
BRAKE
LIGHT
SWITCH
PWG 4
SWITCH
EXTERNAL
SAFETY PATH
ROAD SPEED SIGNAL
DSC
"ROLLING CODE" ISN
EWS 3.3
1999 MY
E38-M73
DME
M5.2.1
(LEV)
Bank II
DME II
INFO.
DUAL ECM
RELAY
CONTROL
DME I
ECM
RELAY
#1
ECM
RELAY
#2
FUEL PUMP
RELAY
CONTROL
P
"ONE TOUCH"
STARTER
RELAY
SEC AIR INJECTION
STAGE II RELAY CONTROL
SHROUDED
FUEL INJECTOR
AIR CONTROL
O2 SENSOR HEATING
PRE CAT
POST CAT
FULLY SEQUENTIAL
FUEL INJECTOR
CONTROL
IGNITION COIL
CONTROL
IGNITION COIL
POWER
RELAY
PURGE
VALVE
CONTROL
DME I
EML IIIs
CAN BUS
DSC III STEERING
ANGLE SENSOR
CAN BUS
CAN BUS
DSC III
EDC
AGS
E-CAT MODULE
TD (ENGINE SPEED)
20 PIN PLUG
D2 PROTOCOL (TXD II)
ISO 9141
PROTOCOL
OBD II
CONNECTOR

AUXILIARY FAN CONTROL

The Auxiliary Fan motor incorporates an output final stage that activates the fan motor at variable speeds.

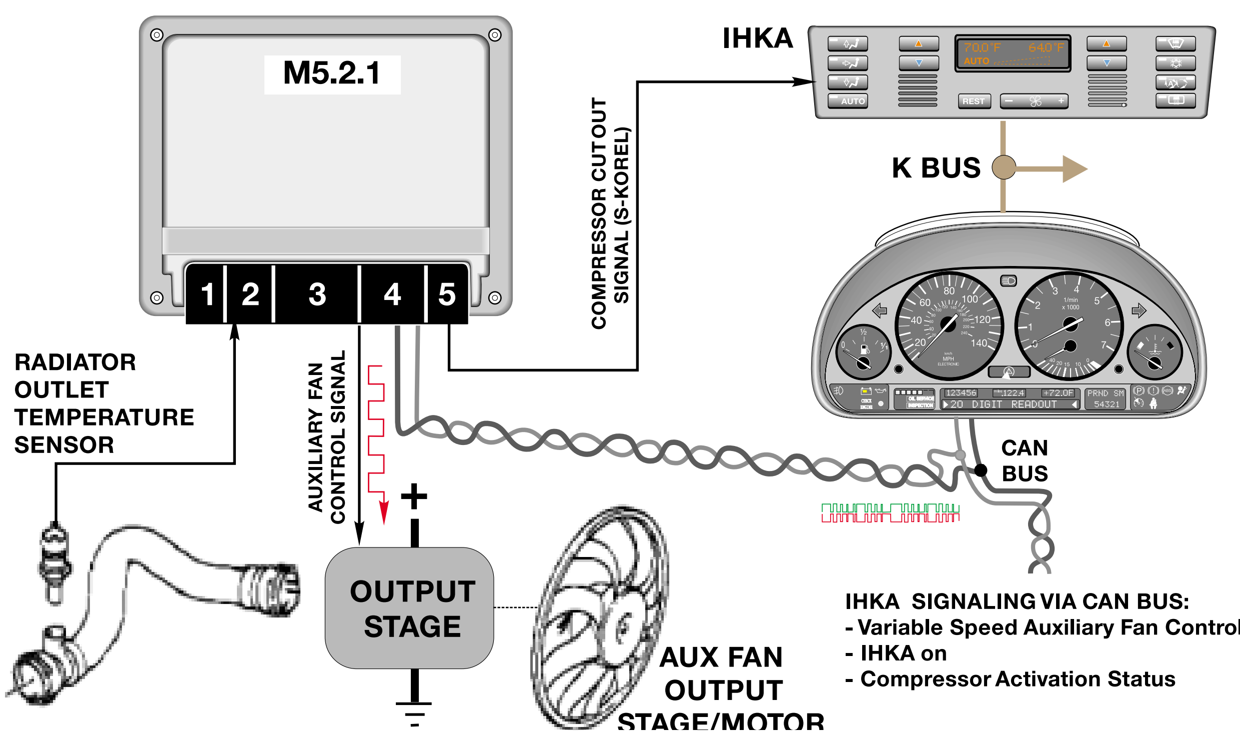


The auxiliary fan is controlled by M5.2.1 ECM. The motor output stage receives power and ground and activates the motor based on a PWM signal (10 - 100 Hz) received from the ECM.

The fan is activated based on the following factors:

- Radiator outlet temperature sensor input exceeds a preset temperature.
- IHKA signalling via the K and CAN bus based on calculated refrigerant pressures.
- Vehicle speed
- Battery voltage level

When the over-temperature light in the instrument cluster is on (120°C) the fan is run in the overrun function. This signal is provided to the ECM via the CAN bus. When this occurs the fan is run at a frequency of 10 Hz.



SECONDARY AIR INJECTION SYSTEM

The purpose of the secondary air injection system is to provide fresh air to the catalytic converters during the warm-up phase of operation immediately after cold start. This accelerates oxidation of hydrocarbons and brings the catalytic converters to the point of light-off earlier.

The M73 TU secondary air injection system continues to be a two speed system utilizing two relays and a slow speed resistor. The introduction of the M5.2.1 ECMs allocated a dedicated control circuit for the vacuum vent valve improving comprehensive component monitoring. This continues with the M73 TU M5.2.1 system.

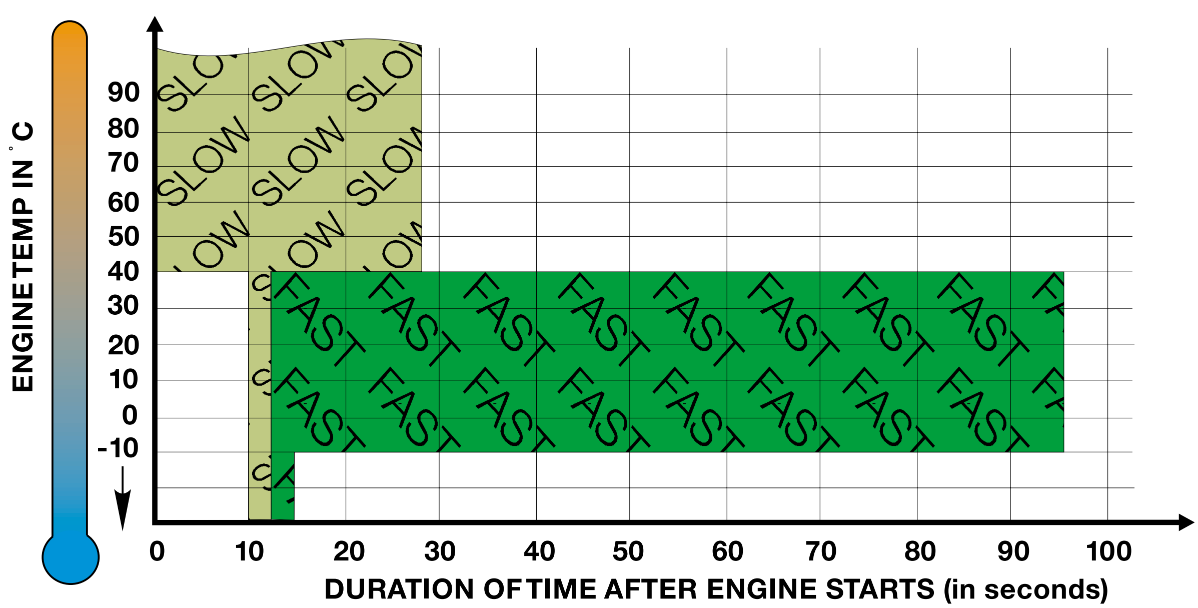
However, the primary controller of the Secondary Air Injection System has switched for the 1999 model year (M73 TU - M5.2.1)

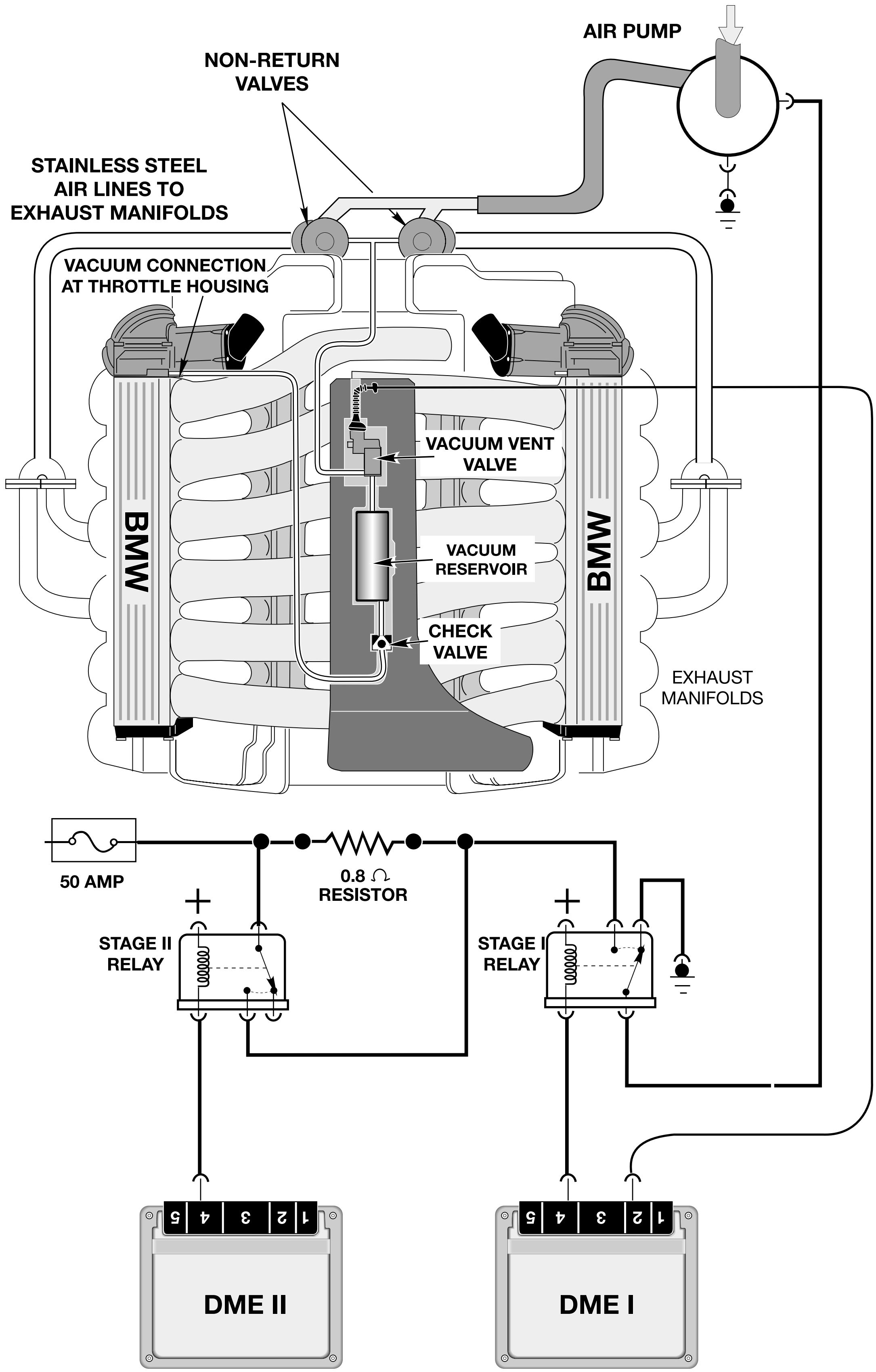
- ECM I activates the vacuum vent valve and Stage I relay simultaneously but separately providing the open air ports through the non return valves and slow air pump speed.

- ECM II activates the resistor bypass circuit through activation of the stage II relay providing the fast air pump speed if necessary.

All parameters of operation are programmed in the M 5.2.1 control modules and varied by monitored conditions:

- Engine Temp
- Engine Speed
- Engine Load




AIR PUMP
NON-RETURN VALVES
STAINLESS STEEL AIR LINES TO EXHAUST MANIFOLDS
VACUUM CONNECTION AT THROTTLE HOUSING
VACUUM VENT VALVE
VACUUM RESERVOIR
CHECK VALVE
EXHAUST MANIFOLDS
BMW
BMW
50 AMP
0.8 Ω RESISTOR
STAGE II RELAY
STAGE I RELAY
5 4 3 2 1
5 4 3 2 1
DME II
DME I

ELECTRICALLY HEATED THERMOSTAT

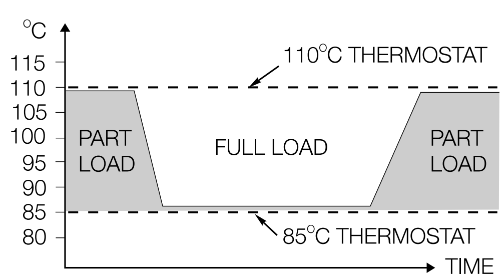
Model specific variants of the electrically heated thermostat are now equipped on all LEV compliant engines. The M73 TU thermostat housing has a quick connect coupling.

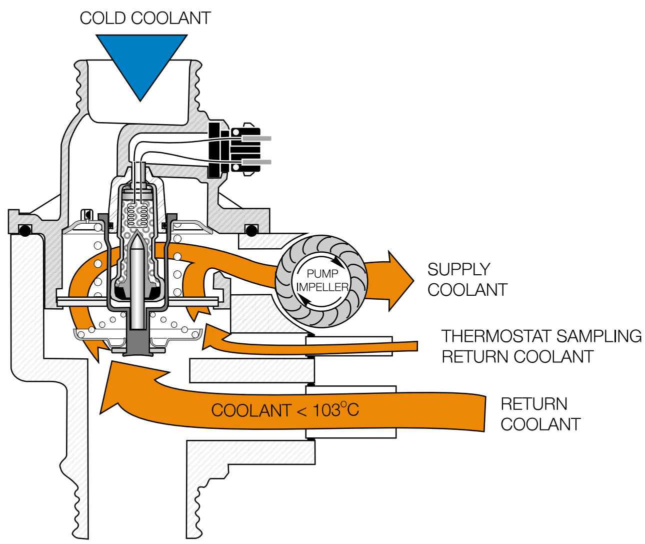
This thermostat allows the engine to run hotter than conventional thermostats improving fuel economy. The ECM also electrically activates the thermostat to lower the engine coolant temperatures based on monitored conditions. It is both a conventionally functioning and ECM controlled thermostat (two stage operation). ECM control adds heat to the wax core causing the thermostat to open earlier than it's mechanical temperature rating providing increased coolant flow.

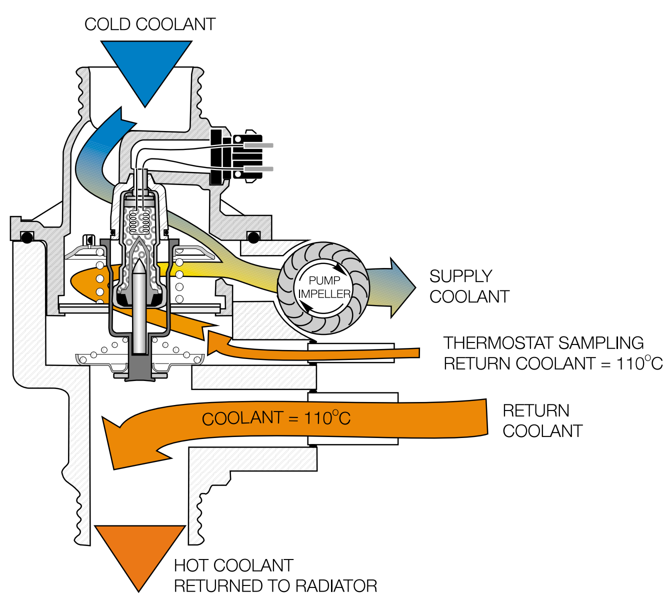
CONVENTIONAL FUNCTION: The thermostat begins to open at 103°C. This is at the inlet side of the water pump and represents the temperature of the coolant entering the engine. Before the 103°C temperature is realized, the coolant is circulated through the engine block by the water pump.

After the temperature reaches 103°C it is maintained as the inlet temperature by the thermostat. The coolant temperature at the water pump engine outlet is approximately 110°C. The additional 7°C is achieved after the coolant has circulated through the block.

The operating temperature of the engine will remain within this range as long as the engine is running at part load conditions and the engine coolant temperature does not exceed 113°C.







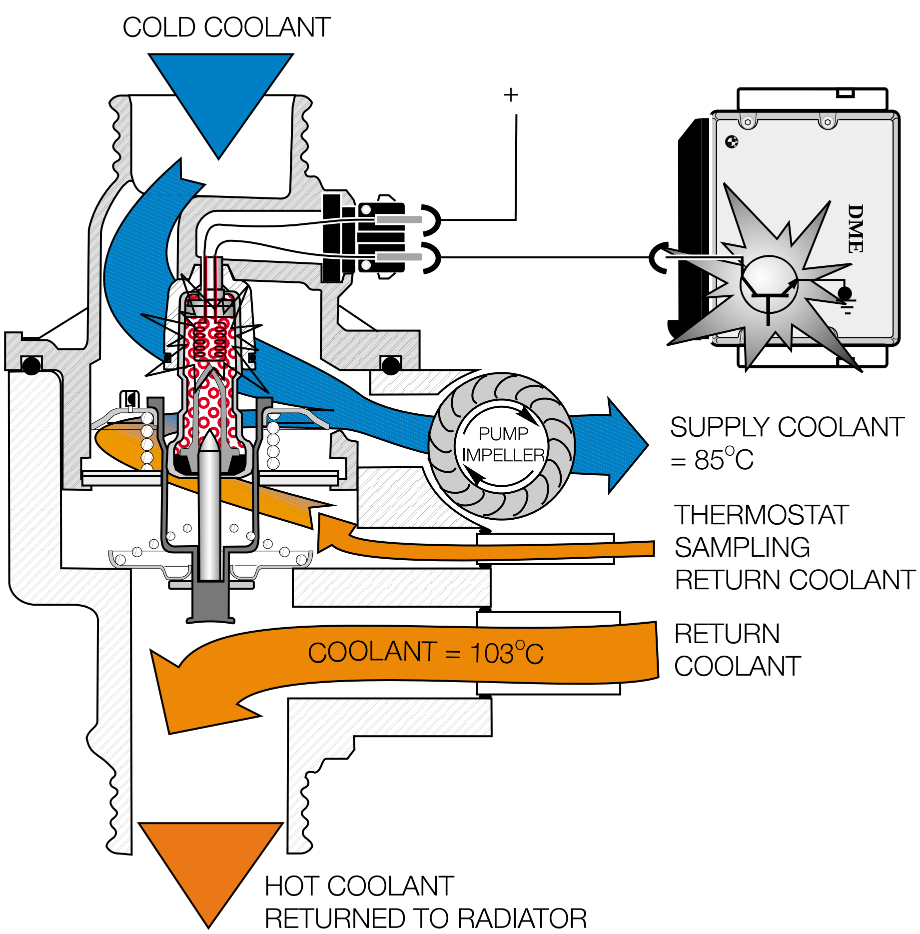
ECM CONTROL

Electric thermostat activation is based on the following parameters:

- Engine temperature > 113°C
- Radiator Coolant Outlet Temperature
- Load signal “ti” > 5.8 ms
- Intake air temp > 52°C
- Vehicle speed > 110 MPH

When one or more of these monitored conditions is determined, the ECM activates (switched ground) the thermostat circuit. The activated heating element causes the wax core in the thermostat to heat up and open the thermostat increasing coolant circulation through the radiator which brings the engine temperature down.

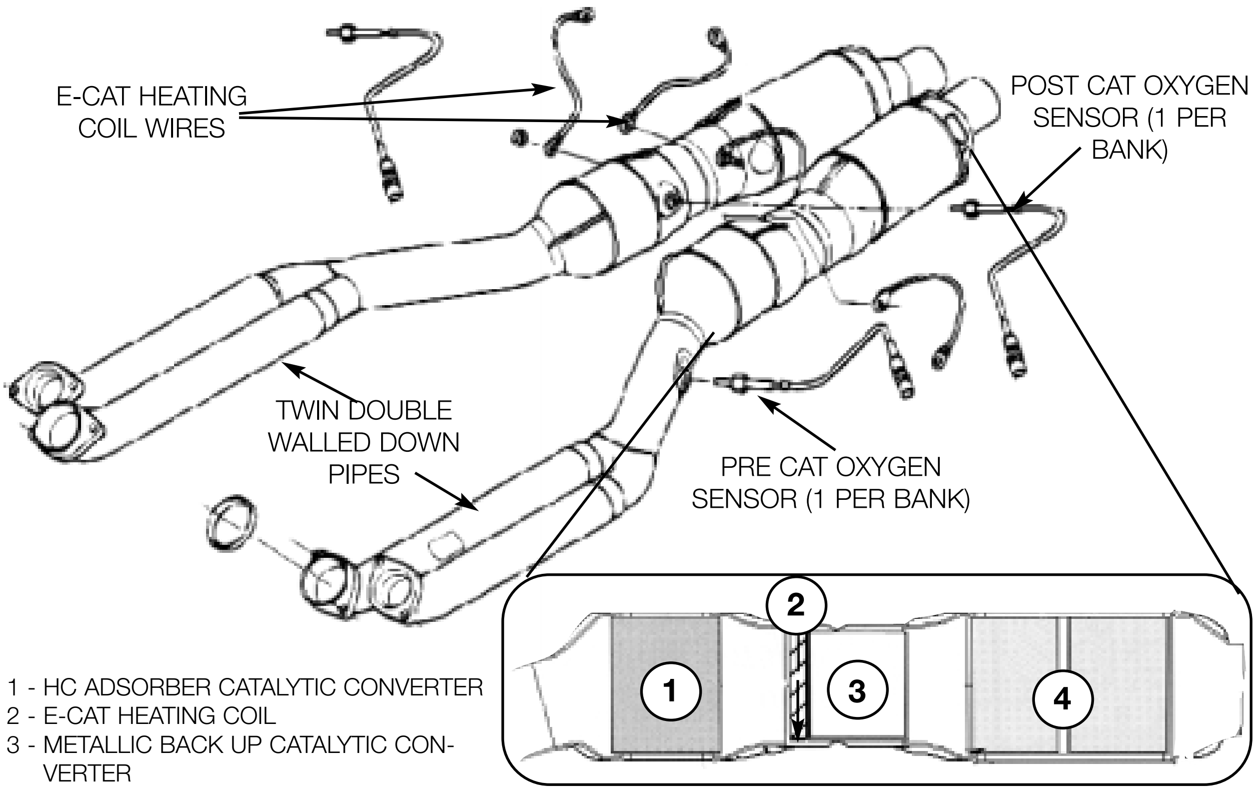
The temperature of the coolant at the inlet side of the water pump will drop to approximately 85°C and the temperature at the outlet side will drop to approximately 103°C when activated.



M73 TU EXHAUST SYSTEM

The 750iL exhaust system consists of the following:

- Each cylinder bank has two double-walled down pipes which converge into a single pipe for entry into the ***integrated electric catalytic converter assembly.***



1 - HC ADSORBER CATALYTIC CONVERTER
2 - E-CAT HEATING COIL
3 - METALLIC BACK UP CATALYTIC CONVERTER
4 - MAIN CATALYTIC CONVERTERS

INTEGRATED ELECTRIC CATALYTIC CONVERTER ASSEMBLY

- Integrated catalytic converter assembly including:
  - Hydrocarbon (HC) adsorber in thin-wall ceramics (105.7 mm dia.)
  - Electric catalytic converter heater and metallic backup converter (80 mm dia.)
  - Main catalytic converters in thin-wall ceramics (105.7 mm dia.)
- Twelve liter volume Central muffler.
- Two rear mufflers with a volume of 18 liters each.

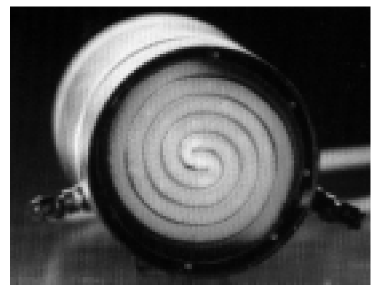
The location of the post oxygen sensor is just behind the HC adsorber and complies with the ARB catalytic converter monitoring function following the same criteria with the familiar post oxygen sensor signal. However, the metallic backup and two main converters are not monitored.

The ARB allows this configuration since the adsorber catalytic converter is the critical element in the assembly. The logic being, if the adsorber is detected as being defective the entire assembly requires replacement.

ELECTRIC CATALYTIC CONVERTER (E-CAT) ASSEMBLIES

The name “Adsorber” identifies the first converter of each assembly as a unique critical component. The Adsorber has the unique ability to attract and retain residual hydrocarbon molecules as it cools. As it warms up it releases the residual HC allowing it to be converted as it passes through the heating coil, back-up metallic converter and twin main converters. This feature is what makes this catalytic converter so unique providing cleaner cold starts and LEV compliance.

The proportion of HC in the exhaust is very high just after a cold start. This is due to the rich fuel/air mixture and incomplete combustion. When initially driving away and during an increase in acceleration which follows, the HC proportion sharply increases again.

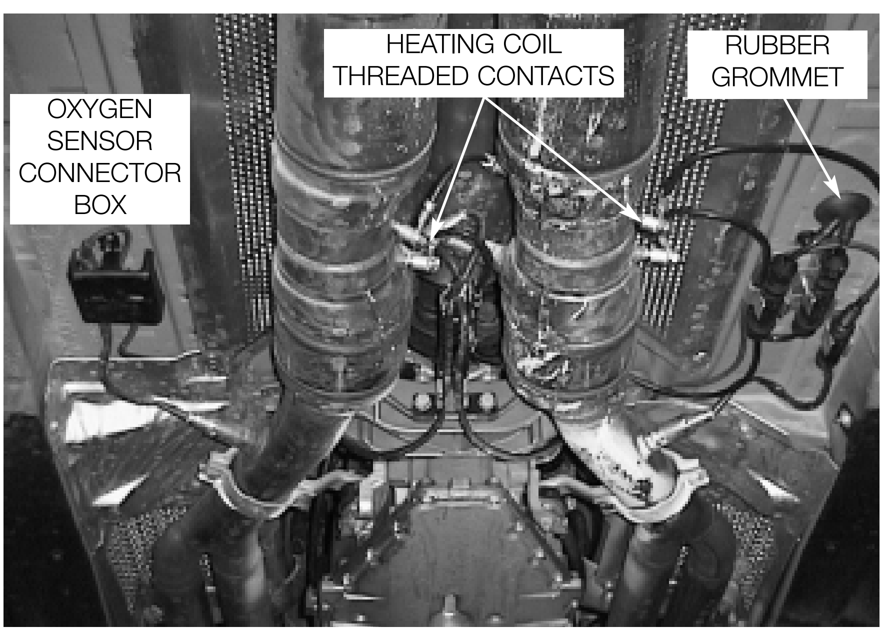


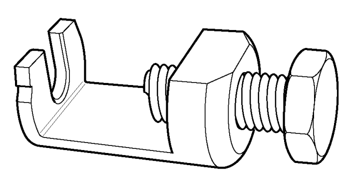
The electric catalytic converter's heating coil, which is installed directly behind the adsorber, is energized for a maximum of 30 seconds immediately after the engine has started (engine speed > 400 rpm). This ensures that the metallic back-up converter and the main catalytic converters downstream attain light-off much earlier.

The heating coils are provided operating current from an E-CAT control module located under the passenger seat. The coils are connected to the E-Cat control module by high amperage cables. The cables pass through a rubber grommet on the passenger side floor to the E-CAT module location.

Special Tool Note: The cables must only be removed from the catalytic converters with tool *90 88 6 180 050.* This tool is designed to prevent damage to the ceramic insulation on the threaded contacts.

Refer to SI 04 02 99.

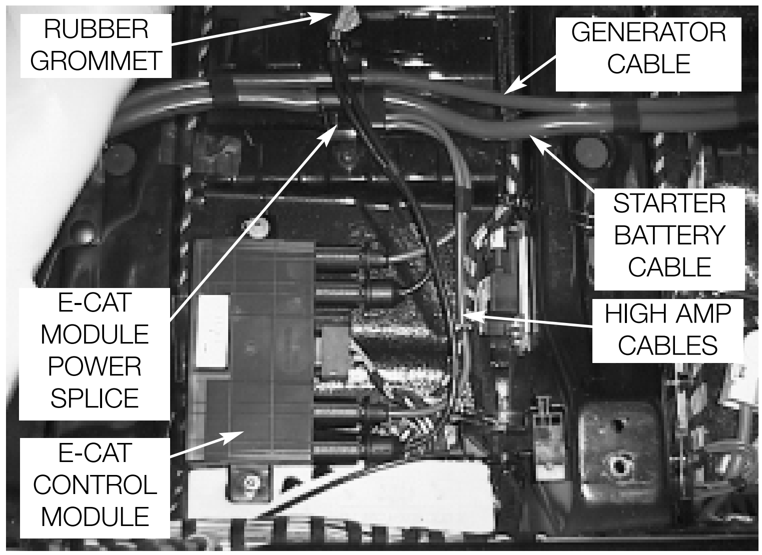




E-CAT CONTROL FUNCTION

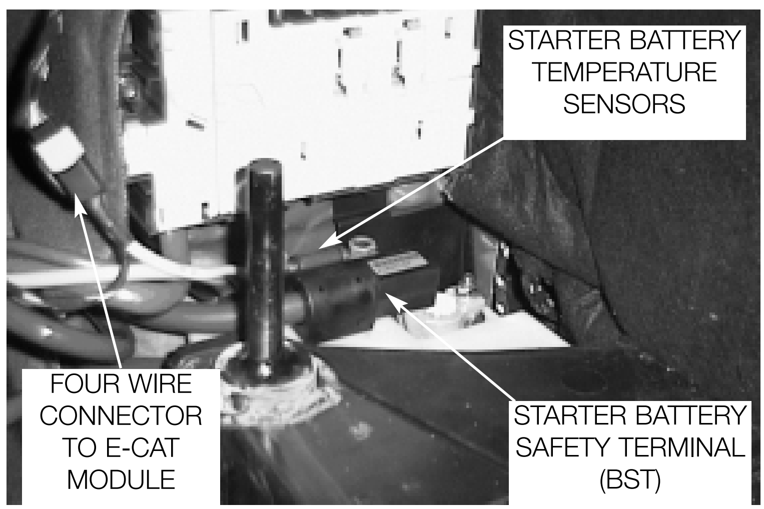
The primary function of the E-CAT control module is to simultaneously control the heating of both E-CAT heating coils through high amperage (120A each) power output switches. ECM I signals the E-CAT module via the CAN bus requesting activation and deactivation of the heating coils. Heating time is for a maximum of 30 seconds but can be shorter in duration depending on monitored conditions.

When on, the metallic back-up converters which are located just behind the heating coils, heat up rapidly. As a result, catalytic converter light-off starts almost immediately reducing cold start emissions in the warm-up phase.



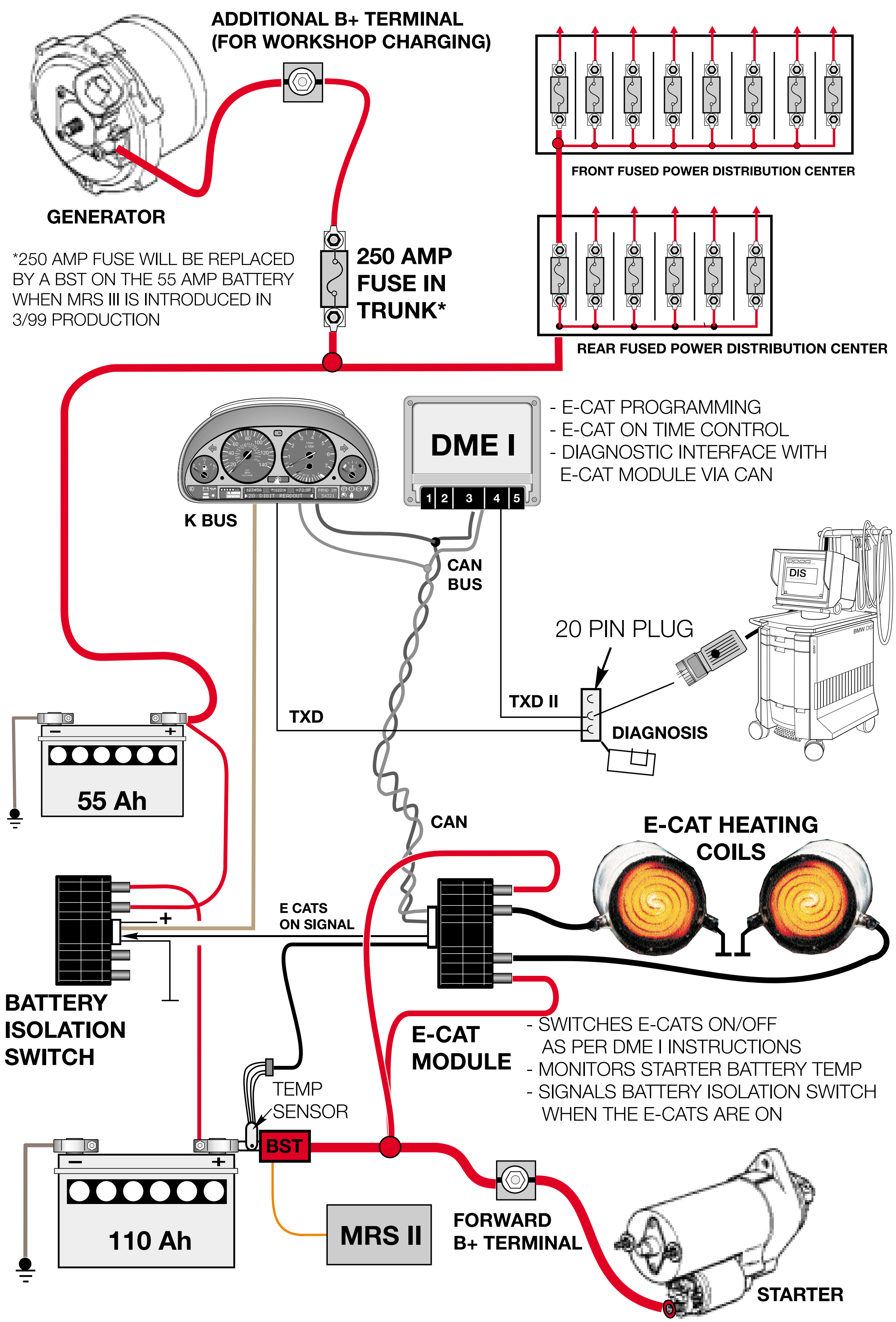
The E-CAT module receives two redundant starter battery temperature signals for monitoring the battery temperature.

The sensors are located in a sealed housing connected directly to the positive terminal of the battery.



If the starter battery temperature falls below 0°C, the E-CAT heating coils are not switched on.

Once the E-CATs are activated, the control module simultaneously provides the output control signal to the dual battery isolation switch (signal KATON) requesting the switch which opens the circuit between the starter battery and vehicle circuit battery. This ensures the E-Cat's operating power is supplied only from the starter battery (detailed description of two battery system further on).


ADDITIONAL B+ TERMINAL
(FOR WORKSHOP CHARGING)
GENERATOR
FRONT FUSED POWER DISTRIBUTION CENTER
*250 AMP FUSE WILL BE REPLACED BY A BST ON THE 55 AMP BATTERY WHEN MRS III IS INTRODUCED IN 3/99 PRODUCTION
250 AMP FUSE IN TRUNK*
REAR FUSED POWER DISTRIBUTION CENTER
DME I
1 2 3 4 5
- E-CAT PROGRAMMING
- E-CAT ON TIME CONTROL
- DIAGNOSTIC INTERFACE WITH E-CAT MODULE VIA CAN
K BUS
CAN BUS
DIS
20 PIN PLUG
TXD II
TXD
DIAGNOSIS
55 Ah
CAN
E-CAT HEATING COILS
E CATS ON SIGNAL
BATTERY ISOLATION SWITCH
E-CAT MODULE
- SWITCHES E-CATS ON/OFF AS PER DME I INSTRUCTIONS
- MONITORS STARTER BATTERY TEMP
- SIGNALS BATTERY ISOLATION SWITCH WHEN THE E-CATS ARE ON
TEMP SENSOR
BST
110 Ah
MRS II
FORWARD B+ TERMINAL
STARTER

CRITERIA FOR E-CAT HEATING COIL ACTIVATION

All conditions for switching the E-Cats on are monitored and activated by ECM I. ***Maximum*** heating time is 30 seconds. The degree of “on” time (calculated amount of necessary E-Cat heating) is dependent on the intake air and coolant temperatures as well as the duration of time the engine has been off since the last trip.

Engine start recognition is determined by the ECM on the basis of various input signals (mass air flow, engine speed etc.). All of the following criteria must be met for the coils to be switched on:

- Engine coolant temperature > 0°C and < 90°C
- Starter battery temperature > 0°C and < 60°C
- Distance travelled since last engine start > 1 mile.
- Catalytic converter temperature < 300°C (programmed temperature map)
- > 30 min since engine was previously switched off
- Vehicle road speed < 3 mph
- Engine starting time < 5 seconds
- Time after start recognition > 0.1 seconds
- Throttle pedal not at WOT

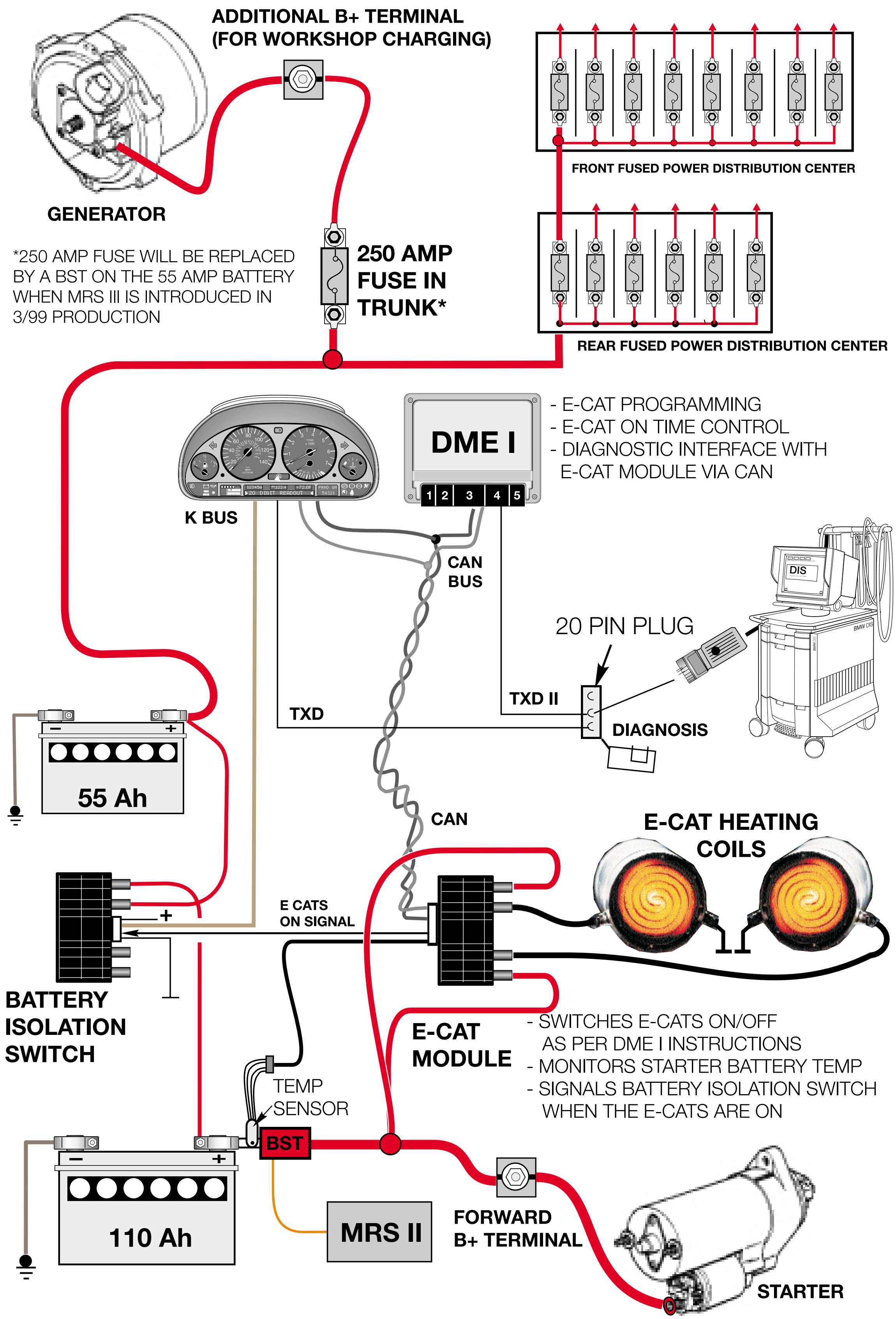
The E-CAT's are immediately switched off when one or more of the following faults occur during an activation period:

- CAN bus fault -- Instrument Cluster
- CAN bus fault -- ECM and E-CAT module
- Fuel injector fault
- Misfire detection faults which might damage catalytic converter
- Fault in output stage of secondary air injection components
- Fault in engine temperature signal
- Fault in engine speed sensor

DIAGNOSIS

The E-CAT module communicates fault information to ECM I via the CAN bus. The ECM relays the diagnostic communication to the DIS/MoDiC. A maximum of 14 E-CAT fault codes can be retrieved through ECM I.

E-CAT specific faults with an illuminated "CHECK ENGINE" Light indicates there have been two unsuccessful attempts to heat the catalytic converters.



ADDITIONAL B+ TERMINAL
(FOR WORKSHOP CHARGING)
GENERATOR
FRONT FUSED POWER DISTRIBUTION CENTER
*250 AMP FUSE WILL BE REPLACED BY A BST ON THE 55 AMP BATTERY WHEN MRS III IS INTRODUCED IN 3/99 PRODUCTION
250 AMP FUSE IN TRUNK*
REAR FUSED POWER DISTRIBUTION CENTER
DME I
1 2 3 4 5
- E-CAT PROGRAMMING
- E-CAT ON TIME CONTROL
- DIAGNOSTIC INTERFACE WITH E-CAT MODULE VIA CAN
K BUS
CAN BUS
DIS
20 PIN PLUG
TXD II
TXD
DIAGNOSIS
55 Ah
CAN
E-CAT HEATING COILS
E CATS ON SIGNAL
BATTERY ISOLATION SWITCH
E-CAT MODULE
- SWITCHES E-CATS ON/OFF AS PER DME I INSTRUCTIONS
- MONITORS STARTER BATTERY TEMP
- SIGNALS BATTERY ISOLATION SWITCH WHEN THE E-CATS ARE ON
TEMP SENSOR
BST
110 Ah
MRS II
FORWARD B+ TERMINAL
STARTER

Review Questions

1. How is the power supply for the ignition coils is provided?________________________
____

2. Describe the Air Shrouded Injector Control on the M73:__________________________
____
____
____
____

3. If the engine idle speed is higher than normal on an M73, what does this indicate?
____
____

4. What will cause a complaint of “engine cranks but does not start”: ________________
____
____
____

5. How many speeds will the Secondairy Air Injection Pump run at and what controls this? ______ ____
____

6. Explain what happens when the ECM activates the thermostat circuit: _____________
____
____
____
____

7. Why is it necessary to use Special Tool # 90 88 6 180 050 when working on an electrically heated catalyst? ____
____

8. What will cause an E-CAT to be switched off?
_____________________ _____________________ _____________________
_____________________ _____________________ _____________________
____

9. Where is the E-CAT Module Power Splice located? ______________________________
____
____